DEVELOPMENT OF REPAIR PROCESSES AND SOURCES FOR B-52 AIRCRAFT WINDOWS/WINDSHIELDS

REPORT

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COLUMBUS, OH 43201

FEBRUARY 1996

TECHNICAL REPORT FOR 09/91 - 12/31/95
CONTRACT NUMBER FO9603-90-D-2217-SD02

PREPARED FOR
OKLAHOMA CITY AIR LOGISTICS CENTER
TINKER AFB, OK 73145

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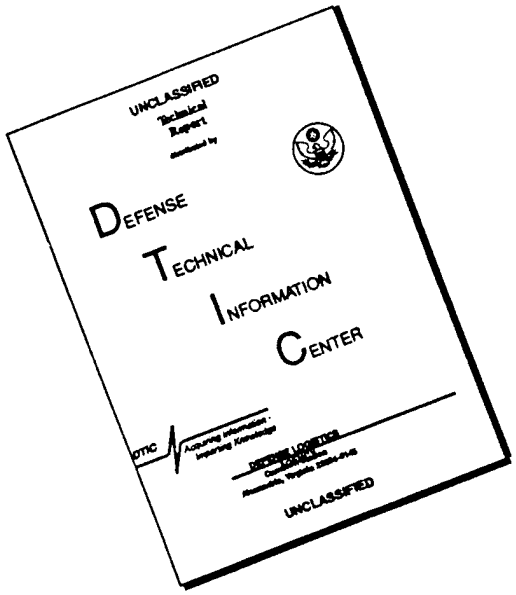

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To assess the viability of using repaired W/WS, some used B-52 W/WS were procured, repaired, and then tested. The repair costs provide the data for the cost benefit analysis. The test results provide the technical evaluation data.

The test results indicate that repaired W/WS are not equal to new W/WS. Many of the repaired W/WS still contain defects that would not pass an OEM quality assurance inspection. The bird impact test results are quite clear - the new W/WS outperform either repaired or unrepaired W/WS, with one repaired W/WS failing catastrophically.

The direct cost of repaired W/WS is less than half the cost of new W/WS. Thus, money can be saved by using repaired W/WS.

Poor performance of the repaired W/WS in the bird impact tests makes it difficult to recommend the use of repaired B-52 W/WS. Because the W/WS that were tested came off of retired aircraft and were not removed for cause, there is a concern for active B-52 W/WS.

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SUMMARY

To reduce fleet maintenance costs, the Air Force is considering using repaired glass cockpit windows/windshields (W/WS). Based on reported cost savings and favorable experience that commercial fleets have had with repaired W/WS, the use of repaired W/WS seems very attractive. In order to determine whether or not significant savings can be realized without a performance penalty, the Air Force funded a study to perform structural testing on and a cost analysis of repaired W/WS.

The approach followed for evaluating whether the use of repaired W/WS should be pursued was to procure some used B-52 W/WS, make repairs on them using a number of different vendors, and then subject the repaired W/WS to a series of tests to determine how they perform. The cost to make the repairs provides the data for the cost analysis. The test results provide a technical basis for determining whether repaired W/WS are acceptable.

The test results indicate that repaired W/WS do not perform as well as new W/WS. Many of the repaired W/WS still contain defects that would not pass an OEM quality assurance inspection. The repaired W/WS would not, however, likely be removed for cause from an aircraft. None of the W/WS tested, whether new, repaired, or not repaired, exhibited any dramatic differences in pressure integrity. Some delamination occurred in a few of the repaired W/WS during pressure cycling, but it was not severe. Delamination was also observed in the new B-52 W/WS.

The most demanding structural test is the bird impact. B-52 #1 W/WS were tested at 250 knots, while B-52 #2 W/WS were tested at 300 knots. The bird impact test results are quite clear. The new W/WS outperform either repaired or unrepaired W/WS. Some of the repaired and unrepaired W/WS showed no evidence of damage. Others, however, failed catastrophically allowing the bird to enter the cockpit.

Costs for making the repairs were less than half of the cost of a W/WS. This suggests that money can be saved by using repaired W/WS. However, because the structural performance of the W/WS is decidedly below that of new W/WS, the use of repaired W/WS cannot be recommended. There was no substantive difference in W/WS performance for repairs made by different vendors.

PREFACE

The work reported herein was performed by Battelle, Columbus, Ohio, under Air Force Contract FO9603-90-D-2217-SD02, "Development of Repair Processes and Sources for C/KC-135 and B-52 Aircraft Windows/Windshields." The program was directed by the Oklahoma City Air Logistics Center (OC-ALC) at Tinker Air Force Base. Air Force administrative direction was provided by Ms. Cindy Cooper, OC-ALC/LADCB. Air Force technical direction was provided by Mr. Robert Koger, OC-ALC/TIETR.

The work was performed during the period of September 1991 to December 1995. The technical program at Battelle was directed by Mr. Richard Olson of Battelle's Engineering Mechanics Department. The author wishes to acknowledge Mr. Wayne Fisher and Mr. Jim Hood of PPG Industries, Inc. Aircraft Products Division in Huntsville, Alabama for their conscientious effort in performing the W/WS testing, and Mrs. Verna Kreachbaum at Battelle for her efforts in preparing the manuscript.

1.0 INTRODUCTION

1.1 Background

Many commercial airlines currently use repaired glass cockpit windows/windshields (W/WS) to reduce their operating costs. For commercial fleets, W/WS represent the fifth highest airplane operating expense, behind engines, fuel, tires, and brakes. Because the cost of repairing a cockpit W/WS can be substantially less than the purchase price of a new W/WS, there is an incentive to use repaired W/WS. Commercial fleets have used repaired W/WS for a number of years and have had favorable experience with them.

The U.S. Air Force (USAF) has not joined the commercial fleets in endorsing the use of repaired W/WS. With decreasing Congressional funding for the military, however, measures to reduce fleet operating costs are receiving greater scrutiny. Decreasing the lead time and procurement costs for W/WS and gaining more control over the spare parts inventory are the benefits that could be obtained by using repaired W/WS. Thus, the use of repaired W/WS is being given serious consideration.

In September 1991, the Air Force contracted with Battelle to investigate the feasibility of using repaired glass cockpit W/WS. The mission of the study was to gather structural performance and cost data to either support or refute a proposal to use repaired W/WS. The initial stage of the program looked at C/KC-135 W/WS cockpit W/WS. The results of this study[1] suggested that repaired W/WS do not perform as well as new W/WS and that the economics of using repaired W/WS was marginal. To be certain that this information had broad applicability, a similar feasibility study was subsequently undertaken using B-52 W/WS. This report documents the findings from the B-52 W/WS portion of the study.

1.2 Objective

The objective of the work reported herein is to provide the technical and cost data needed to justify a decision by the Air Force on whether or not to use repaired glass cockpit W/WS.

1.3 Approach

The approach followed for evaluating whether use of repaired W/WS is a viable option for the Air Force was to procure some used W/WS, make prototypical repairs on them, and then subject the repaired W/WS to a battery of tests to see if there is any difference in performance when compared with new W/WS. Making prototypical repairs provides baseline data for repair costs. The battery of tests provides an evaluation of fitness for purpose of the repaired W/WS.

1.4 Report Contents

In the sections that follow, the results of this 1¼-year study on B-52 W/WS are presented. The discussion begins with a generic presentation about glass aircraft W/WS and ends with recommendations for the Air Force concerning the use of repaired glass W/WS. Topics presented include:

- A review of glass cockpit W/WS construction and damage
- A discussion about the selection and repair of W/WS in this program
- W/WS test results
- A cost analysis
- Conclusions and recommendations.

2.0 B-52 GLASS W/WS

2.1 Construction

To provide a context for discussing W/WS repairs, it is important to understand the construction of glass cockpit W/WS. Figure 2.1 shows the general construction of the glass B-52 W/WS. The W/WS have a three-part glass and vinyl laminate construction. The inner layer is thick, heat-strengthened plate glass designed to withstand cabin pressure forces. A transparent, plasticized, polyvinyl butyral core layer acts as the "fail-safe" load carrying member and prevents shattering in the event of inner ply failure. The outer ply is a relatively thin layer of heat-strengthened glass with no structural significance, but it provides rigidity and a scratch-resistant surface. A phenolic or masonite filler strip, located around the edge of the W/WS, and a metal filler strip embedded in the vinyl provide the means to attach the W/WS to the airframe. Vinyl or vinyl and rubber bumpers protect the edges of the glass plies.

The structural integrity design of B-52 cockpit W/WS is based on two requirements: "fail-safe" pressure integrity and bird impact resistance. The "fail-safe" pressure integrity is founded on two redundant systems, an inner glass ply that can sustain the full rated cabin pressure in the absence of all other layers, and a polymeric core ply that can maintain pressure integrity if the inner and outer glass plies are cracked. The bird impact structural integrity of W/WS is either characterized as "bird bagging" or "bird bounce." Bird bagging W/WS, typically two glass layers with a polymeric core ply, stop bird penetration by large ductile deformation of the core ply, i.e., "bagging" the bird. Bird bounce W/WS are typically multi-laminates and cause the bird to "bounce" off the W/WS. The B-52 cockpit W/WS are "bird bagging" W/WS.

The glass used in B-52 W/WS is heat strengthened to provide resistance to cracking. The glass is heated to near the softening point and then quenched to produce compressive residual stresses that extend from the outer surface into a depth of about $1/6^{th}$ of the glass thickness. Below the compressive stress layer lies tensile residual stresses, see Figure 2.2. As long as surface defects do not penetrate into the tensile layer, the glass will exhibit a high resistance to fracture. Once a crack does fully penetrate the tensile layer, the glass will shatter as the tensile stresses are relieved.

The vinyl core, which acts as the "fail-safe" pressure boundary and means for controlling glass fragments in the event of a glass ply failure, is highly plasticized polyvinyl butyral. The vinyl is relatively brittle at low temperatures (-65° F), and unable to absorb much energy per unit volume. At temperatures approaching 130° F, the vinyl becomes very ductile and can absorb a relatively large amount of energy as it is loaded. W/WS heaters, which not only de-fog and de-ice the glass, ensure that the vinyl remains ductile.

An integral part of the B-52 W/WS construction is slip planes or a parting medium at the edges of the glass. A slip plane is located between both the inner glass ply and the vinyl and the outer glass ply and the vinyl as shown in Figure 2.1. The slip planes are thin strips of material at the glass-vinyl interface that keep the glass from bonding to the vinyl. This allows the various plies to move independently at these locations in response to pressure loads and differential thermal expansion. Without the slip planes, the glass at the edges of the W/WS

would be prone to fracture because it would exceed its strain limit as it tried to move with the underlying vinyl. The slip planes form a "softer" connection that promotes a more gradual build up of strains in the glass so that it does not exceed its strain capacity. Although the slip planes look similar to delamination, they are not defects but an intentional part of the W/WS design.

The B-52 cockpit W/WS contain heating systems for anti-icing and/or anti-fogging. An electrically conductive film of pyrolytic tin oxide between the outer glass ply and the vinyl core ply is used to heat the W/WS to reduce ice/frost formation. A similar conductive film between the inner ply and core ply is used on some W/WS for defogging only. The W/WS heating system, so called NESA® coated glass, uses the resistivity of the film to provide the heating. The temperature of some W/WS is controlled with an integral sensor embedded in the laminate. The sensor, a negative temperature coefficient thermistor, exhibits increasing resistance with increasing temperature. When hooked into an appropriate power amplifier circuit, the electrical power applied to the W/WS is modulated to keep the W/WS temperature within a specified band. Externally applied thermal switches control the temperature on other W/WS.

Seals on the W/WS keep cabin pressure in and moisture out. In addition, they act as vibration and shock absorbers and help to compensate for differential thermal expansion between the W/WS and the airframe. B-52 W/WS use either molded-in-place seals or pre-made polysulfide rubber seals that are glued onto the W/WS frame with polysulfide rubber. All of the W/WS, except the escape hatch W/WS, mount from the inside of the aircraft. Drawing the W/WS tight to the airframe with mounting bolts effects the seal.

Many of the W/WS on the B-52 are flat. The W/WS directly in front of the pilot fall into this category. Because they are flat, they are easy to manufacture and repair. In addition, they have very good optics. Several of the W/WS are curved. Some of them have a single axis of curvature, while others have compound curvature. The curvature tends to result in some degree of optical distortion, and the curvature makes it somewhat more difficult than flat W/WS to repair, in spite of the fact that the curved W/WS are generally smaller than the flat ones.

2.2 Damage

The most common failure modes of laminated glass transparencies are:

- Delamination: separation of vinyl from the glass
- Cracks and chipping: glass breakage due to high stress
- Arcing: unbalanced electrical potential within the conductive coating
- Heater Failure: loss of continuity in the heater or sensor circuit or low power
- Impaired Vision: due to surface scratches, contaminates, or internal defects

- Contamination: air or water leaks caused by defective seals
- Vinyl cracking.

Delamination is separation of the glass surface of the inner or outer ply from the vinyl core ply to which it is bonded. Delamination generally starts at the slip planes and moves inward, although it may occur anywhere in the W/WS. It mainly occurs between the outer ply and the vinyl ply. Delamination does not dramatically reduce the strength of the W/WS, but may interfere with vision or W/WS heating if the delamination occurs at the interface where the heating film is located.

Cracks and chips may occur in either of the glass plies and may be caused by impacts or by high stresses at the edges of the glass. Single cracks in the outer ply are unlikely because the temper in this layer precludes a single crack. After the momentary appearance of a crack in the outer layer, the entire layer shatters very abruptly. Small cracks very near the edges of the W/WS may not be cause for removal, provided the crack is not directed toward the center of the pane. Cracks that adversely affect the functioning of the heater would not be acceptable. Chips may occur internally or externally. Internal chips are caused by the glass-vinyl bond strength exceeding the strength of the glass. External chips are generally caused by impacts. Chips usually have a clamshell shape, are rough, and white powdered glass is often in evidence. Chips are detrimental to the strength of the pane.

W/WS busbar breakdown and faults in the heater film cause arcing. Basically, the insulation breaks down and the heater electrical current short circuits to the airframe. Arcing is evidenced by burned areas around electrical braid and along the busbar.

The failure of the W/WS heater to de-ice or defog satisfactorily is one of the most serious failure modes. Arcing, chips, cracks, or lack of continuity in the heater film that render the heater inoperative are cause for W/WS replacement. Uneven heating or hot spots caused by delamination at the glass-vinyl interface with the heating film or chips may also be a cause for removal. As W/WS age, the resistance of the heater generally rises. In order to provide the same power for defogging or de-icing, the voltage applied to the W/WS must be increased. At the maximum possible voltage (which is governed by the design of the W/WS autotransformer and the current carrying capacity of the wiring to the W/WS), if the W/WS heater resistance is above allowable specifications, the heater will be perceived as being ineffective.

Satisfactory optical properties of the W/WS are paramount. Foggy or cloudy areas may appear in places where moisture has penetrated the vinyl and has begun to degrade it. Scratches may occur on both the inner and outer plies that may interfere with visibility. Likewise, delamination may become serious enough to warrant replacement of the W/WS on the basis of reduced visibility. Bubbles may occur in the vinyl core ply in W/WS that have been exposed to elevated temperatures. Bubbles are caused by gas liberated from the vinyl, and grow in size and number with increased temperature or longer exposures. Needless operation of the heaters on the ground is a prime cause of bubbles. Bubbles do not have a large effect on strength of the W/WS, but may become serious enough to impair visibility.

Although other failure modes may not be evident, poor optical performance is always a sufficient cause for W/WS replacement.

The bumpers on the edges of the glass form a moisture barrier. Degradation of bumpers in the form of cracking or separation from the edge of the glass ply can allow moisture and air to get into the slip planes. Moisture can degrade the heater film with consequent initiation of heater failure, arcing, delamination, and contamination.

As a result of aging, cracks may occur in the vinyl. Over time, attack by ultraviolet radiation and high temperatures also causes the vinyl to lose ductility. Eventually, cracks may form around the periphery of the W/WS in proximity to the metal insert as the glass and vinyl try to move relative to one another. Vinyl cracks significantly weaken the structure of the W/WS by putting flaws directly in the load path between the transparency and the airframe for bird impact loads. Per Figure 2.1, only the vinyl extends out to the mounting holes, not the glass. Therefore, if the vinyl is cracked near the metal insert, the W/WS could just "punch out" of the frame into the cabin in a bird impact situation. The vinyl layer is also the pressure "fail-safe" layer, so vinyl cracks are quite important.

In addition to cracking, the vinyl layer may discolor or darken if it is subjected to temperatures in excess of 225° F. Foreign substances in the glass-vinyl interface, either from in-service conditions or introduced as a part of a repair process, may also cause discoloration.

2.3 Repairs

The manufacture of a new W/WS is conceptually quite simple - two layers of glass are bonded together with vinyl under heat and pressure to form an optically acceptable transparency. Likewise repairing a damaged W/WS is also conceptually simple - rebond separated laminates, and remove unacceptable scratches, chips, and cracks. Unfortunately, although the concept of manufacturing a new W/WS or repairing a damaged one is quite simple, the implementation requires a great deal of "art" and practice to become skilled at making successful repairs.

Economical glass cockpit W/WS repairs are generally limited to the exterior surfaces that are accessible without disassembling the windshields. In exceptional cases, when the cost of a new W/WS is high, W/WS can be disassembled for repair by separating the glass and vinyl layers.

W/WS repairs can be conveniently divided into four categories:

1) Electrical heater system repairs

   Electrical heater repair is limited to re-connecting the resistive wiring when the resistance reading is infinite. W/WS with resistance readings outside the acceptable ranges, other than open circuits, are deemed un-serviceable.

   An open circuit can possibly be repaired by manually soldering the accessible breaks in the electrical braid. Corrosion can be removed from exposed terminal blocks using a fine grade abrasive. Repair of open or arcing busbars can also be

effected by injecting a conductive adhesive material at the glass-vinyl interface where the busbar defect is located.

2) Delamination

Delamination between the glass and vinyl plies of the W/WS greater than 40-percent of the W/WS area, or vinyl tearing is deemed unserviceable and the W/WS is scrapped. The use of an autoclave to laminate glass sheets, laminates, and transparencies is cited in a number of patents. A 1967 PPG Industries Inc. patent, # 3,311,517[2], cited an oil autoclave curing cycle of "up to 30 minutes or more at a temperature of about 190 to 325 degrees Fahrenheit, preferably about 225 to 300 Fahrenheit, and simultaneous pressures of between 100 and 250 pounds per square inch, depending on the thickness of the components of the assembly to be laminated and the number of interfaces between the components."

The use of autoclaves that use oil to apply pressure to the W/WS has been superseded by autoclaves that apply pressure using air, with the W/WS in vacuum bags. Repair of delamination by injection of adhesives into the W/WS is also possible.

3) Surface defects

Repairable "minor" surface defects such as scratches, up to 0.005 inches deep, can be polished, then blended to avoid optical distortion. Cracks or chips in the glass panels are not repairable, and the W/WS is deemed non-serviceable and scrapped.

a. Spot polishing is mostly performed as a manual bench-top operation using hand-held, air-powered tools, such as palm sanders, with either bonded sheet abrasives or loose rare earth compound abrasives such as cerium oxide. Stationary polishing belts are also available. However, it is not feasible to manually feed a 60-70 pound windshield for any length of time. Polishing is a messy operation because it is usually done wet, requiring much manual effort and skill, and it relies extensively upon operator experience.

Manual glass surface polishing on strengthened (tempered) glass is not widely performed outside of the aircraft industry because it is time consuming and the success is low due to the ease of introducing optical distortion. Aside from airplane W/WS, it is generally cheaper to replace a scratched W/WS than it is to polish it. For a 0.005-inch deep scratch, the defect would have to be "feathered out" over a width of ± 3.82 inches to preserve an optical deviation of 4.5 arc minutes, the standard for C/KC-135

#1 W/WS in the center viewing area of the W/WS. For a relatively large flat W/WS (B-52 center W/WS) polishing may take in excess of 12 hours.

b. In exceptional cases, where a new W/WS is very expensive, a scratched front glass ply and the underlying vinyl can be removed and replaced. The criterion for whether or not this operation is justified is the new W/WS cost versus polishing cost versus ply replacement cost.

4) Seals and bumpers.

Seals on all W/WS can be replaced and bumpers can be cleaned up or repaired. The seals on the W/WS are either of the cast-in-place type, or the glue-on type. To replace a seal, the old one must first be peeled off and the W/WS frame surface cleaned, and a new seal installed.

The exposed edges of the glass, in some W/WS designs are protected with a vinyl, vinyl and rubber, or all rubber bumper either integral with the W/WS or glued on with adhesive. If the bumper has separated from the glass or if sealant that overcoats the bumper is damaged, the old sealant is removed by cutting and scraping and new sealant is reapplied to ensure that the W/WS is moisture-tight.

3.0 W/WS REPAIRS MADE FOR THIS PROGRAM

There currently are five prominent commercial aircraft W/WS repair vendors: NORDAM Transparency Division; Perkins Aircraft Services, Inc.; The Glass Doctor; PPG Industries, Inc. Aircraft Products Division; and Pilkington Aerospace, Inc. Each of these companies has developed the necessary techniques and skills to become an FAA-certified W/WS repair station. In all cases, the concepts involved in their repair processes are as simple as described above. The actual reduction to practice of the concepts, however, is either treated as a trade secret or is covered by patents.

3.1 Repair Vendors

3.1.1 NORDAM Transparency Division

NORDAM Transparency Division is one of the world's largest privately held, FAA-approved transparency repair stations, providing comprehensive overhaul capabilities on glass and acrylic W/WS. Located in Tulsa, Oklahoma, NORDAM has more than 15 years experience in the repair and overhaul of aircraft W/WS.

Repairs that NORDAM is authorized to make include relaminating, surface polishing, and seal rehabilitation. Autoclave curing of delamination, bubbles, voids and interlayer vinyl cracking is done with the same laminating cycles, times and methods utilized in the original manufacture of the W/WS. Polishing includes removal of scratches, chips and pits from the outer glass or acrylic and inner plies. Original optimum optics are restored with the least amount of surface material removal, in accordance with strict adherence to OEM manual limits for removal. Seal rehabilitation includes cleaning, repairing, or replacing of seals as required. NORDAM is authorized by the FAA under Air Agency Certificate EZ22812K to make the W/WS repairs. Appendix A has a copy of the certificate.

3.1.2 Perkins Aircraft Services, Inc.

Perkins Aircraft Services, Inc. specializes in the overhaul and repair of both monolithic and laminated aircraft transparencies made of glass or acrylic. Located in Ft. Worth, Texas, Perkins is an FAA-approved repair facility authorized to make in-plant and "on the aircraft" repairs.

A five-step process is used by Perkins to restore damaged W/WS to an FAA-serviceable condition. First, all incoming W/WS are given a thorough inspection to determine whether the W/WS can be repaired. W/WS with out-of-specification electrical systems or that are otherwise judged unrepairable are rejected and returned. The second step of the process is repair of delamination. Using a proprietary autoclave process, the W/WS are heated and pressed to rebond the W/WS layers. Polishing, the third step in the W/WS repair process, is done to remove scratches, chips, and in the case of plastic W/WS, crazing, using automated polishing machines. The fourth step is reassembly. In this step, the transparencies are matched up to their original frames, as applicable, and seals and gaskets are replaced. The

final step in Perkins' W/WS repair process is to perform a quality assurance inspection to ensure that all of the necessary repairs have been made and that the W/WS has been restored to OEM specifications. Perkins holds FAA Air Agency Certificate JKQR257L, see Appendix A, which authorizes them to operate their W/WS repair station.

3.1.3 The Glass Doctor

The Glass Doctor of St. Petersburg, Florida got into the aircraft transparency repair business in 1979 after working in the automobile windshield repair business for 10 years. Starting with cabin window repairs, the business has expanded to also include FAA-approved repair of all cockpit W/WS as well as cabin windows.

The Glass Doctor has developed special techniques for repairing chips, nicks, and delaminations in W/WS. Unlike the other aircraft W/WS repair vendors, The Glass Doctor does not rely solely upon polishing and re-autoclaving of the W/WS to effect the repairs. As described in U.S. patents #3,841,932[3], #3,914,145[4], and #4,780,162[5], The Glass Doctor repairs conical cracks by filling the crack with a polymerizable resin that is vibrated into place by motion of the conical plug, see Figure 3.1. Delamination repairs can be made by injecting an adhesive between the delaminated plies per Figure 3.2. Conventional autoclave relamination and polishing for scratch and distortion removal is also done.

Using experience gained from their delamination repair techniques, The Glass Doctor has also developed the unique capability to replace failed W/WS heater sensors and can repair open or arcing busbars. Failed heater sensors are replaced by drilling into the vinyl and potting a new sensor in the hole. Open or arcing busbars are repaired by injecting a conductive adhesive material at the glass-vinyl interface where the busbar defect is located. Although there is some controversy in the aircraft W/WS repair industry associated with the repairs that The Glass Doctor makes, repairs are under warranty for up to 3 years (scratches excluded), and the reported rate of warranty work is very low.

The Glass Doctor operates its W/WS repair station under FAA Air Agency Certificate OX4R430M. A copy of The Glass Doctor's certificate is attached in Appendix A.

3.1.4 PPG Industries, Inc. Aircraft Products Division

PPG's Aircraft Products Division, located in Huntsville, Alabama, has been in the aircraft transparency business since 1926 and is an OEM supplier for B-52 W/WS, as well as many other military, commercial, and general aviation aircraft W/WS. The Huntsville plant is America's largest and most modern facility for producing aircraft transparencies. It fabricates W/WS with heat strengthened and chemically tempered glasses, as-cast and stretched acrylics, and polycarbonates for commercial, military, and general aviation aircraft. The W/WS repair services that PPG offers include scratch removal, gasket and seal rehabilitation, relamination, upgrade to the latest revision, and replacement of broken outer plies for all glass-faced Boeing and Douglas W/WS that were originally manufactured by PPG. PPG warranties the revision level upgrade and ply replacement for 36 months, while other repairs are warranted for 12 months. The PPG W/WS repair facility has been in operation since May 1994, and is operated

under FAA Air Agency Certificate IL4R262M. A copy of the certificate is attached in Appendix A.

3.1.5 Pilkington Aerospace, Inc.

Pilkington Aerospace of Garden Grove, California, is the combined organization of Swedlow, Inc. and Triplex Aircraft & Special Products Limited, operating as a fully owned subsidiary of Pilkington plc., the world's largest producer of glass and allied products. Pilkington is an OEM for: 1) Commercial transport aircraft glass frontal W/WS, plastic and glass-plastic composite side W/WS, and stretched acrylic cabin W/WS, 2) Military aircraft W/WS including free-formed stretched acrylic and laminated canopies, as well as transport aircraft glass front W/WS, and 3) Commuter and rotary wing aircraft stretched acrylic, glass-polycarbonate laminate, and glass-PVB laminate W/WS. Pilkington is authorized to repair W/WS for all models of Boeing, Douglas, Airbus, Saab, Lockheed, Fairchild, and British Aerospace aircraft. Repairs include scratch removal, relamination, and replacement of the front ply on glass-laminate W/WS. Pilkington's repair facility is operated under FAA Air Agency Certificate P9AR279J. A copy of Pilkington's FAA certificate is included in Appendix A.

3.2 Program Prototype Repair W/WS

The B-52 has 13 cockpit W/WS; a front center one and six on each side of the aircraft. The #3 W/WS on each side of the B-52 can slide on a track. Figure 3.3 shows the location and numbering scheme for the B-52 W/WS. All B-52 W/WS are not glass; the #6 W/WS is made of stretched acrylic plastic. Table 3.1 lists the current glass W/WS part numbers for the B-52.

OC-ALC supplied 118 B-52 W/WS to Battelle by having them removed from retired aircraft at AMARC. The W/WS consisted of pilot-side and copilot-side #1, #2, and escape hatch W/WS. The B-52 W/WS were not removed from the flight line for cause. Rather, they were taken from retired aircraft that had been on active duty.

After the B-52 W/WS were removed from the aircraft and shipped to Battelle, the W/WS were evaluated to see if they were suitable for repair. In spite of the fact that the W/WS had not been removed for cause and were on previously active duty aircraft, 67 of the W/WS were found to be out of specification on heater or sensor resistance, or else the glass was chipped. The unrepairable W/WS were destroyed and the remaining 51 formed the pool from which repair candidates were selected.

3.3 Vendor Selection

The W/WS repair vendors used in this program were paid for their services. The repairs were made at the vendors' prevailing commercial rates, with vendors selected by competitive bid. Vendors were given descriptions of the condition of W/WS to be repaired and then asked to give rough estimates of the costs to repair a fixed number of the different W/WS on the

B-52. None of the vendors had any direct experience making B-52 W/WS repairs, although they work with similar W/WS in their commercial business. Repair specifications for the B-52 W/WS, provided to the vendors by Battelle, came from the B-52 Technical Orders[6], W/WS drawings[7-9], and W/WS OEM design specifications[10-12].

Quotations for repairing B-52 W/WS were solicited in August 1994 from NORDAM, Perkins, The Glass Doctor, PPG, and Pilkington. Contracts for making repairs were negotiated with The Glass Doctor and PPG. The Glass Doctor and PPG were each sent 7 #1, 7 #2, and 3 escape hatch W/WS for repair. From the W/WS sent, each vendor was to repair 4 #1, 4 #2, and 2 escape hatch W/WS, as mutually selected by Battelle and the vendor. PPG repaired the contracted number. The Glass Doctor repaired all of the W/WS sent to them (17) for the contracted price of 10.

3.4 Prototype Repairs

Tables 3.2 through 3.4 provide the details of the condition of the B-52 W/WS and the subsequent repairs that were made to them. In the list, two items are worthy of special mention. First, The Glass Doctor made delamination repairs on the W/WS by injecting clear adhesive into the W/WS. Second, on one #1 and one #2 W/WS, The Glass Doctor did a sensor replacement. The service history of the prototype repair candidates is not known because: 1) very few of the W/WS had airframe numbers, 2) the Air Force does not track W/WS by serial number, and 3) planes are moved from location to location as a part of normal squadron rotation. In most instances, the date of removal from service was not noted. The installation date is not known for any of the W/WS. All that is known for certain is the year the W/WS was made; the first one or two digits of the serial number indicate the year the W/WS was made - a single digit is a 1970's vintage W/WS.

4.0 REPAIRED W/WS STRUCTURAL INTEGRITY TESTING

4.1 Test Philosophy

The fitness for purpose of the repaired B-52 W/WS was evaluated using a rigorous test program. In formulating the test program, the plan was to select a set of tests that would assess the critical performance elements of the W/WS: general fitness-for-purpose characteristics, pressure integrity, and impact resistance. By suitable selection of test parameters, the goal was to gather data to establish whether or not repaired W/WS perform as well as new W/WS.

4.2 Test Plan

The test plan was developed as a joint effort between Battelle, OC-ALC, and the Flight Dynamics Laboratory at Wright-Patterson AFB. The primary reference for the test plan was the testing done previously on C/KC-135 W/WS[1]. A secondary source of information used to formulate the test plan was the B-52 W/WS drawings [7-9] and design/test specifications.[10-12] Upon reviewing the available B-52 W/WS information, it became clear that the B-52 W/WS design predates specification of anything but pressure load integrity. Thus, the B-52 specifications were only of limited value. The test plan, therefore, was developed from the C/KC-135 test experience and the open literature on W/WS testing[13-26].

In order to assess whether the performance of the repaired W/WS is satisfactory, a standard for comparison must be defined. Obviously, the performance of new W/WS should be the basis for the comparison. Simply stated, the repaired W/WS should, ideally, perform just like new W/WS. In the best situation, information for new W/WS would be available to define the required tests for the repaired W/WS and the existing new W/WS data would form the basis for the comparisons. The information available from Boeing and OC-ALC suggested that data on prior B-52 W/WS testing was sparse or very difficult to retrieve, so the scope of the testing program had to include tests of new W/WS to generate the baseline new W/WS performance data. In addition, because of uncertainty in setting some of the parameters for the tests (load levels, primarily), the test program included a methodology phase verification to establish that the new W/WS would pass the tests. Although testing of new W/WS was primarily a response to the lack of readily available new W/WS test data, it does facilitate the process of making the comparisons because both new and repaired W/WS were tested under absolutely identical conditions.

Appendix B is a copy of the test plan. The test plan incorporates all of the relevant W/WS test information gleaned from the B-52 Tech Orders, W/WS specification documents, and W/WS drawings. Knowledge gained during the C/KC-135 W/WS testing[1] factored heavily in the design of the test plan. The test plan was submitted to and approved by OC-ALC.

Three major types of tests were conducted on the repaired prototype W/WS and the companion new W/WS:

- A thorough visual/electrical/optical inspection
- Pressure/thermal cycles
- Impact testing.

The repaired prototypes and new W/WS were all given the inspections and then a fraction of the W/WS was subjected to each of the other two types of tests.

4.3 Testing Subcontractor

The testing was conducted at PPG Industries, Inc. Aircraft Products Division in Huntsville, Alabama, based on a competitive bid. PPG has been in the aircraft transparency business since 1926 and is an OEM supplier for B-52 W/WS. As a leader in the field of aircraft transparency technology, PPG has built an impressive W/WS qualification testing facility. PPG's capabilities include bird impact testing, environmental testing, high strain rate material evaluation, dynamic deflection analysis with high speed photography, dynamic stress analysis with strain gages, and ballistic testing for transparent armor. In performing the tests for this program, PPG used the same test fixtures, test procedures, and QA requirements in use today to make new W/WS for B-52's. These capabilities at a single site, coupled with their intimate knowledge of the B-52 W/WS proved valuable to this program.

PPG conducted the testing in accordance with the test plan. As a quality assurance activity, the testing was monitored by visits to the test facility by Battelle staff. No indication was ever detected that PPG attempted to influence the outcome of any of the tests for their own gain (PPG is an OEM supplier of B-52 W/WS). All work was done to the highest professional standards using instrumentation calibrated in accordance with PPG Quality Control procedures.

4.4 General Inspections

General electrical/optical/mechanical testing of repaired W/WS was performed to ensure that each W/WS is in specification electrically, that the repair operations have not adversely affected optical qualities, and that the fit and finish is correct.

All of the W/WS tested in this program were initially given a thorough 14-item inspection by the PPG Quality Control Department. The inspection included:

1) Locating and recording the customer part number
2) Locating and recording the W/WS serial number
3) General visual inspection
4) Gasket/seal evaluation

5) Thickness measurements at prescribed locations

6) Physical tolerance check

7) Bus-to-bus resistance

8) Sensing element resistance

9) Electrical insulation integrity test

10) Heater operation test

11) Heating film scratch test

12) Luminous transmittance and haze measurement

13) Optical deviation measurement

14) Optical distortion photograph.

With little exception, the indication of which W/WS were new, repaired, or unrepaired was difficult to determine from a superficial visual examination. Only a detailed technical examination, equivalent to an OEM post-production quality control check, was able to uncover differences between the W/WS.

4.4.1 General Visual Examination

A visual examination was performed on each W/WS to assess its general condition. During this inspection, the part number and serial number were located and recorded, the W/WS was checked for delaminations and vinyl cracks, and the condition of the seal was evaluated.

4.4.2 W/WS Dimensional Measurements

The repair of delaminations may involve re-autoclaving of the W/WS to rebond the vinyl inner layer to the glass. Because the vinyl layer is pressed at an elevated temperature and consequently may flow, the overall thickness of the W/WS may be reduced and the location of power/sensor terminals and bolt holes may shift. In addition, the vinyl may creep from installation clamping pressure/elevated ambient temperature.

To determine if the thickness the W/WS meets specifications, total thickness of the W/WS was measured at selected locations in the viewing area. A 12-point grid was used for all W/WS.

During the testing of C/KC-135 W/WS[1], it was noticed that the mounting edge thickness of some of the old W/WS was significantly less than the thickness of the new W/WS. This, in fact, caused some problems in mounting the W/WS in test fixtures. The root cause for the reduced thickness was vinyl thickness reduction. Because the vinyl is the only structural element that carries load into the airframe in a bird impact, thinning of the vinyl could be considered a serious structural deficiency. Based on the experience with the C/KC-135 W/WS, W/WS edge thickness measurements were included in the B-52 W/WS inspection protocol: The frame thickness was measured at 8 locations around the frame.

A physical tolerance check was made on the W/WS to see if critical dimensions, including proper fit dimensions, location of electrical connections, and bolt hole locations, had been changed by the repairs. Each W/WS was checked using check fixtures used in the original manufacture of these W/WS.

4.4.3 Basic Electrical Measurements

Electrical resistance measurements were made using the standard electrical resistance measurement function on a digital multimeter to determine if the heaters and sensors were within acceptable tolerances. As applicable, both bus-to-bus resistance and sensor resistance were measured.

Electrical insulation integrity was checked using a Hipotronics 300 Series Hipot and Megohmmeter at 2500 volts A.C. As applicable, insulation integrity was checked between the power bus and the sensor element and sensor element to the metal frame.

4.4.4 Heater Operation Tests

Sensor operation and heating uniformity were evaluated by infrared imaging. In this test, the W/WS was powered with 60 Hertz power at a voltage appropriate to the W/WS heater resistance. During the power up, the ability of the W/WS sensor to regulate the temperature was established. When thermal equilibrium was attained, an infrared imaging system was used to make a photograph of the thermal contours on the glass.

To supplement the thermal imaging heater test, a scratch test of the heater film was performed. In this test, the heater is powered up and the W/WS is viewed using polarized light. Although the vinyl core ply of the W/WS is birefringent, scratches in the heater film show up dramatically as black-gray starbursts.

4.4.5 Optical Performance

The optical performance of each W/WS was assessed in three ways; a haze and luminous transmittance test, an optical deviation measurement, and an optical distortion test.

Haze and luminous transmittance measurements were performed in accordance with ASTM D-1003-92[23]. The luminous transmittance test measures how transparent a body is, and is the ratio of the light transmitted through a body to the light incident upon it. The haze test measures the cloudy appearance of an otherwise transparent specimen caused by light

scattered from within the specimen or from its surfaces. Haze and luminous transmittance measurements will detect whether the repair processes have adversely affected the clarity and/or coloring of the vinyl and whether the glass surfaces have been adequately polished.

Optical deviation measures the flatness of a transparency. In the case of a repaired W/WS, grinding, polishing, and/or uneven pressing to remove delaminations may cause the front and back surfaces of the W/WS to deviate from a parallel condition, causing images to be deformed. An autocollimator measures the flatness of a transparency using the distance between the front surface reflection of a normally directed beam of light and the light reflected from the back surface of the transparency to calculate the angular deviation from parallel. Measurements are given in terms of minutes of angular arc. Optical deviation was measured using MIL-G-25871B Paragraph 4.4.6.2.1[18] and ASTM F 801-83[24] as references at 12 locations on the W/WS. The measurement locations were principally around the edges of the W/WS where deviation is expected to be most severe in a repaired W/WS.

Optical distortion was assessed using MIL-G-25871B Paragraph 4.4.6.3[18] and ASTM F 733-90[25] as references. The distortion was determined by a single-exposure photograph of a grid viewed through the W/WS. Photographs were made with the W/WS parallel to the grid board. Deviation of the grid board lines in the viewing area from parallel indicate distortion. The unit of measure for deviation is the ratio of x lines horizontal to y lines vertical (or vice versa) for lines that are not parallel. A distortion of greater than 1 part in 40 is essentially no distortion.

4.4.6 General Inspection Results

Tables 4.1 through 4.15 summarize the results of the general inspections. In a number of areas, the repaired W/WS are the equivalent of new W/WS - dimensional fit, most optical properties, and heater operation. There are, however, some troublesome areas - scratches, unremoved delaminations, some insulation integrity faults, and a few out of specification heater resistances that suggest that the repaired W/WS are not quite up to OEM standards for a new W/WS. As indicated, most of the general inspection tests had an accept/reject criterion. For the heater tests, and optical distortion, there are no established criteria. For optical deviation, a W/WS was rated as reject if its deviation was noticeably greater than the new W/WS. Figures 4.1 through 4.3 show the worst optical distortion found during the inspections. Appendix C contains the data sheets for the general inspections.

4.5 Pressure Integrity

Pressure integrity was evaluated with a three-step sequence. The first step was a proof pressure test. Samples which passed the proof pressure test then went on to a cyclic pressure durability test. Finally, samples which passed the cyclic durability test were proof pressure tested again.

4.5.1 Proof Pressure Test

This test was performed as an initial acceptance and final test on all pressure integrity test articles. The test candidates were mounted in a test fixture and pressurized at 1.0 psi per minute up to a maximum pressure of 18.6 psi. The maximum pressure was held for 15 minutes and then released at a 1.0 psi per minute rate. The test was conducted at ambient temperature. At completion of the test, the W/WS were inspected for delamination and electrical resistance.

4.5.2 Cyclic Durability Test

This test was performed on all W/WS that passed the initial proof pressure test. The test was conducted with an outward-acting constant amplitude cyclic pressure varying from zero to a specified maximum pressure at a specified rate. Both inboard and outboard environmental conditions were specified. The cyclic pressure was to be applied until failure was observed or run out, with run out determined by the OEM W/WS design qualification specifications. Tables 4.16 and 4.17 summarize the cyclic durability test conditions.

Marking of delaminations on the surface of the outer ply and then photographing the W/WS served to document any visual damage to the W/WS. Mode of failure and a photograph of the failed test article were to be used to document specimens that did not survive this test.

4.5.3 Pressure Test Facility

The test facility for conducting the pressure integrity testing utilized PPG's Environmental Qualification Test Facility. This facility has three walk-in environmentally controlled chambers that can be used to expose transparencies to temperatures as low as -100 F and as high as +185 F. Pressure chambers with mounting flanges for transparencies fit into the wall of the environmental chambers to permit simultaneous pressure and temperature control, per Figure 4.4. Internal heating and cooling capacity, as well as small fans inside the pressure chambers ensure that the transparency inboard conditions can be maintained, independent of the outboard conditions.

The pressure integrity test W/WS were mounted in simulated frames made from aluminum or steel plates. The rationale for using simulated frames was; 1) less expensive than using an actual fuselage section, and 2) a simulated frame could be made much stiffer than the sheet metal fuselage section and thus would maximize potentially damaging deformation in the W/WS. The W/WS were bolted to the simulated frames using hardware equivalent to that used in the actual aircraft W/WS installation kits. Figure 4.5 shows a typical set-up for a pressure integrity test.

4.5.4 Test Results

The results of the pressure integrity testing are presented in Tables 4.18 through 4.20. None of the W/WS, repaired or new, exhibited any catastrophic failures. Some of the repaired

W/WS did experience delaminations, and evidence of delamination was detected in the new B-52 W/WS. The worst delamination in the B-52 W/WS is shown in Figures 4.6 through 4.8. In these figures, the edge of the delamination has been outlined with a black marker. None of the W/WS exhibited delamination that would cause the pilot to be unable to see through the W/WS.

4.6 Bird Impact Testing

The bird impact testing on #1 and #2 W/WS was conducted using ASTM F330-89[26] as a model. The W/WS were mounted in a simulated frame placed at the correct inclination and sweepback angles for level flight and impacted with a real 4-pound bird in the center of the W/WS. The B-52 W/WS were impacted at a range of velocities from 200 to 400 knots. Testing was done at room temperature, performing a single shot on each W/WS. A spall sheet was placed behind the W/WS.

Simulated frames were used in the bird impact tests which were similar to the ones used in the pressure integrity tests. The rationale for using simulated frames was the same as in the case of the pressure integrity tests. Mounting hardware and installation procedures were consistent with the applicable B-52 Tech Orders.

Bird weight, high speed film of the impact, impact velocity, pre- and post-test photographs, a record of the disposition of the spall sheet, and written comments from a post-test examination of the W/WS documented each test.

4.6.1 Test Facility

PPG's bird impact test facility is one of the most advanced in the world, capable of shooting one to eight pound birds at impact velocities from 30 to 750 knots, depending on the bird weight. The pneumatic cannon has a 40-foot long barrel with a nominal 10-inch diameter. A pressurized reservoir provides compressed air to propel a metal can, called a sabot, containing the bird to the target. When the sabot reaches the end of the barrel after firing, it is collected by a stripper and spring system that absorbs the sabot's kinetic energy. As the bird continues to the target, approximately 10 feet away, it passes through a timing trap system to measure its velocity. Figure 4.9 shows a schematic of the important elements of the bird cannon.

The velocity of the bird at impact is a calibrated function of the air pressure pushing the sabot down the barrel. A dual rupture diaphragm system fires the gun. Assuming that Diaphragms 1 and 2 in Figure 4.9 are rated to burst at P_b psi and that test pressure, P_t, is greater than P_b but less than $2P_b$, putting $\frac{1}{2}P_t$ in the Step Chamber keeps both diaphragms from bursting. Opening the Solenoid Exhaust Valve vents the Step Chamber to atmosphere and causes Diaphragms 1 and 2 to burst almost simultaneously applying test pressure in the reservoir to the sabot.

A massive frame support system, adjustable for inclination angles from 25 to 85 degrees was used to hold the simulated W/WS frame. Figure 4.10 shows the support frame with a #1 C/KC-135 W/WS mounted, ready for testing. To ensure that the test article is in its proper

position, the impact point is identified with a helium/neon laser centered in the end of the barrel. Installation angles were measured with a precision clinometer. Figure 4.11 shows a view of the set up for a typical bird impact test.

4.6.2 Bird Impact Test Results

A summary of the bird impact test results is presented in Tables 4.21 and 4.22. A gradation in impact damage for B-52 #1 and #2 W/WS is shown in Figures 4.12 to 4.17. Other W/WS with similar damage look about the same as these figures.

The initial part of the B-52 W/WS bird impact testing was dedicated to finding a suitable test velocity. The original goal was to be able to test at 400 knots. This proved to be a higher velocity than the B-52 W/WS could withstand. Eventually, a 300 knot velocity was selected for the #2 W/WS and 250 knots for the #1 W/WS. (The #2 W/WS can sustain a higher velocity impact because it has both a sweepback and installation angle, i.e., the net angle of incidence of the bird is lower in the #2 W/WS).

PPG's data sheets for the bird impacts are attached in Appendix D.

4.7 Summary

From the data presented, the obvious conclusion is that used W/WS do not perform as well as new W/WS. Although trends are difficult to identify in the data because there always seem to be exceptions and because the data base is so small, the performance of W/WS that have been in service, whether repaired or not, is below that of new W/WS.

In a number of categories, the repaired W/WS were the equal of new W/WS: dimensional fit, most optical properties, and heater performance. In other cases, they were not: residual delamination, delamination during pressure cycling, scratches, and poorer performance in the bird impact testing. Some of the issues, such as scratches and residual delamination, can easily be rectified. The delamination during pressure cycling is merely annoying because it is an impaired vision issue that would develop over time and is not a serious structural failure.

The B-52 W/WS bird impact tests showed some alarming results. First, the target 400 knot impact velocity could not be reached. If there are B-52 missions that call for low-level high-speed flight above 250 knots, there is a risk of a bird impact catastrophically failing a W/WS and perhaps initiating a crash. Second, one of the repaired W/WS failed catastrophically at the test velocity. This either suggests that the velocity to be bird impact "safe" using repaired W/WS is lower than the test velocity or else there is a higher bird impact damage risk when using repaired W/WS. Third, there is a large amount of scatter in the data which does not lend itself to generalization of the results.

5.0 COST ANALYSIS

The second element in the evaluation of the feasibility of using repaired W/WS in Air Force fleet aircraft is a cost analysis. The commercial fleet has a very favorable cost benefit using repaired W/WS. If using W/WS is to be a viable option for the Air Force, the costs for making the repairs have to be justifiably less than the cost of a new W/WS.

5.1 Repair Costs

During initial contacts with NORDAM, Perkins, PPG, and The Glass Doctor and prior to contracting for any repairs, an estimate was solicited for repairing small numbers of #1, #2, and escape hatch B-52 W/WS. Based on the estimates, two vendors were selected to make repairs, PPG and The Glass Doctor. Table 5.1 summarizes the estimated repair costs for the W/WS as well as the actual prices that were paid.

5.2 Costs of New W/WS

OC-ALC provided costs for new B-52 W/WS. The data in Table 5.2 is the Air Force purchase price as of January 1994.

5.3 Cost Comparison

The cost for making the prototype repairs on the B-52 W/WS was from one half to one third of the cost of a new W/WS using the actual repair costs as the basis. Using the highest estimated repair cost, a repaired W/WS costs approximately 75-percent of the cost of a new W/WS.

6.0 CONCLUSIONS, DISCUSSION, AND RECOMMENDATIONS

6.1 Conclusions

The Air Force, in an effort to reduce fleet maintenance costs, is considering the possibility of using repaired W/WS. Prior to adopting such an operating policy, however, the Air Force decided that a systematic evaluation was required to ensure that repaired W/WS are safe and that they provide a reasonable cost savings benefit. Based on the reported cost savings and favorable experience that commercial fleets have had with repaired W/WS, the use of repaired W/WS seems very attractive.

The approach followed for evaluating whether the use of repaired W/WS is a viable option for the Air Force was to procure some used W/WS, make repairs on them, and then subject the repaired W/WS to a series of tests to determine the difference in performance when compared with new W/WS. The cost to make the repairs provides the data for the cost benefit analysis. The test results provide the data for an evaluation of fitness for purpose of the repaired W/WS.

The test results indicate that repaired W/WS are not equal to new W/WS. Many of the repaired W/WS still contain defects that would not pass an OEM quality assurance inspection. None of the W/WS, new or repaired, exhibited any dramatic differences in pressure integrity. Some delamination occurred in the repaired W/WS during pressure cycling, but it was not severe. Delamination also occurred in new W/WS. The bird impact test results are quite clear - the new W/WS outperform either repaired or unrepaired W/WS, with one repaired W/WS failing catastrophically.

Cost-wise, the direct cost of repaired W/WS is less than half the cost of new W/WS. Thus, money can be saved by using repaired W/WS. There are other costs which must be considered which will reduce the cost advantage of repaired W/WS: transportation costs, warehousing of removed W/WS, and administering the repair program (procurement, QA inspections, etc.). Even considering these factors, however, repaired W/WS will likely still show a cost advantage.

6.2 Recommendations

The performance of the B-52 W/WS is troublesome in a number of respects. First, none of the W/WS tested in this program was removed for cause. Assuming that repairing a W/WS does not damage it, one would hope that W/WS that came off of operational aircraft and that were only just polished would be reasonably similar in performance to new W/WS. In fact they are not - many of the W/WS in the as-received condition did not meet resistance specifications and one of the repaired W/WS failed catastrophically in a bird impact test that a new W/WS passed. Second, the achievable test velocity for the bird impacts was well below the initial target of 400 knots. This suggests that there is a risk that in a high-speed, low-altitude mission, a bird impact could result in loss of a plane. It is unlikely that even a new W/WS could sustain a 400-knot impact without bird penetration. Third, there is a rather large amount of scatter in the test data - repaired W/WS do not always perform better than

unrepaired W/WS and older W/WS are not necessarily worse than newer W/WS. On average, however, new W/WS are better than repaired or unrepaired W/WS.

Having established that repaired W/WS are not equal to new W/WS, the question that needs to be addressed is whether or not the repaired W/WS are "good enough." The replacement criteria in the B-52 W/WS Tech Orders, are founded on two major principles:

1) A W/WS that has any condition that impairs visibility must be replaced

2) The W/WS heater must function properly.

A number of specific inspection items, subordinate to these principles, provide additional criterion for W/WS replacement. According to the prevailing Tech Order inspection criteria, none of the repaired W/WS would have been removed for cause from service. The fact that they were removed and were subsequently restored to a condition better than the W/WS replacement criterion suggests that they would nominally be considered "good enough." The repair vendors do not claim that they can restore a W/WS to a brand new condition. Rather, they indicate that the repairs they perform return the W/WS to a fully acceptable and functional condition.

In terms of performance, the most demanding test is the bird impact and the evidence suggests that the bird impacts done for this program represent the first-ever B-52 W/WS bird impact tests. Using the criteria set forth in MIL-W-81752A[18] , Paragraph 3.7.2 specifies that the W/WS should be able to sustain a 4-pound bird impact at maximum achievable operational true airspeed in level flight at up to 5000 feet altitude without any spall. This is substantially the same requirement for commercial fleet W/WS set forth in by the FAA for commercial aircraft W/WS[21]. Because the B-52 has a cruising speed of approximately 450 knots and a low altitude penetration speed of approximately 350 knots[27], most of the repaired W/WS fail the no spall criterion.

Faced with the poor performance of the repaired W/WS in the bird impact tests, it is difficult to recommend the use of repaired B-52 W/WS. In a broader context, one could question the adequacy of the design in the light of current W/WS performance standards. In addition, there is some concern that W/WS on aircraft in the active B-52 fleet may need some attention. The high fraction of W/WS that were removed from deactivated aircraft that do not meet resistance specifications suggests that the W/WS in active aircraft probably are also degraded. Although it may not presently be a problem, such degradation may affect the availability of aircraft in critical situations.

These comments notwithstanding, recommendations can be made as a result of the work done in this study.

If, in the opinion of the Air Force, the performance of repaired W/WS is deemed "good enough:"

1) The repairs done by PPG and the Glass Doctor are similar in performance, and restore a W/WS to a condition that exceeds the removal for cause criteria.

2) Based on the results of this study, the repair processes that were used and found not to degrade the performance of the W/WS:

   a) Relaminating using autoclave processes involving application of heat and pressure
   b) Grinding and polishing of the external surfaces of the glass
   c) Seal/bumper maintenance
   d) Minor clean-up of electrical terminals
   e) Delamination repair involving injection of adhesives or filling with transparent polymerizable resins
   f) Sensor replacement by potting with transparent resins.

3) Repair processes that probably would not be detrimental, but that were not tested:

   a) Busbar repair using injection of conductive adhesives. (This is virtually identical to delamination by adhesive injection.)

4) Repair processes that were not tested and therefore cannot be endorsed:

   a) Complete front ply replacement.

5) If repaired W/WS are to be used, a formal Air Force quality assurance (Q/A) program should be instituted to set forth requirements for the repair vendors. This will eliminate the annoying, but easily corrected, problems found during inspections. In addition, this Q/A program should also be charged with performing an incoming inspection of W/WS coming back from the repair vendors.

6) Should repaired W/WS be used, a policy that prevents a W/WS from undergoing more than one repair cycle should be instituted. The contractual requirements for the repair vendors should stipulate that all repaired W/WS must be permanently marked to identify that they have been repaired and by whom. No data have been collected to support the use of re-repaired W/WS.

It is important to emphasize that all of the recommendations offered above are contingent on the Air Force deciding that the performance of the repaired W/WS is adequate.

6.3 Discussion

In reviewing the test data, the question of why one W/WS should perform better or worse than another in a structural test was considered. Four possible causes were identified:

- Vinyl degradation - Vinyl, being a plastic is subject to UV degradation and general aging due to loss of plasticizer. As a result of the aging, the vinyl may become brittle and crack, thus reducing its load carrying capacity in the laminate. The vinyl could also be preferentially squeezed from the edge of the W/WS during a relaminating repair process or in service. Because the vinyl is the only structural ply that carries the load into the W/WS frame for a bird impact, if this occurred, the load capacity of the W/WS would be degraded.

- Grinding/polishing of the glass - The B-52 W/WS use heat-strengthened glass. In producing this type of glass, the ply is heated to near its softening point and then quenched to introduce compressive residual stresses in the surface layers. Tensile stresses inside the glass exist to equilibrate the compressive surface stresses. Because glass only fails due to tensile stresses at the surface, the residual compressive stresses must be overcome to initiate a failure. Grinding and polishing remove some of the beneficial compressive stresses, and hence, the overall strength of the glass ply is reduced. Removal of the highest compressive stress layer, however, must be balanced against removal of flaws. In concert with the obvious effect of removal of the highest compressive stress layer, as far as flaw tolerance goes, the surface may also not be as smooth after grinding/polishing. Smoother surfaces have less flaws and a profoundly higher strength[28].

- Stress corrosion cracking of the glass - The surface of glass contains many microscopic cracks and fissures, and under a sustained load, the presence of moisture exacerbates the growth of these cracks[29-32]. Generally, water vapor in the air is sufficient to cause the degradation. Elevated temperatures and longer exposures accelerate the stress corrosion cracking effect. Although there is no direct evidence that aircraft W/WS degrade dramatically from this phenomenon, the fact that the W/WS are highly stressed due to thermal and pressure loading, they are exposed to atmospheric moisture, they are routinely heated in a high stress state, and that old W/WS performed below new W/WS in the structural tests suggests that there may be more than a casual cause-effect relationship.

- Fatigue - Glass exhibits a complex load rate-cyclic loading behavior. Under a constant maximum load, no effect of cyclic loading is observed, but under increasing maximum load, cyclic loading reduces the strength[33,34]. The net effect for a W/WS undergoing repeated pressure cycles is not clear, but it seems plausible that some amount of micro-crack propagation occurs.

There is no conclusive evidence that the results of this test program can be directly attributed to any of the mechanisms described above. However, it does not seem unreasonable to suggest that they might. As far as the implications for use of repaired W/WS, vinyl degradation, stress corrosion cracking, and fatigue affect both repaired and unrepaired W/WS. Only repaired W/WS would seem to be susceptible to the grinding/polishing degradation mechanism.

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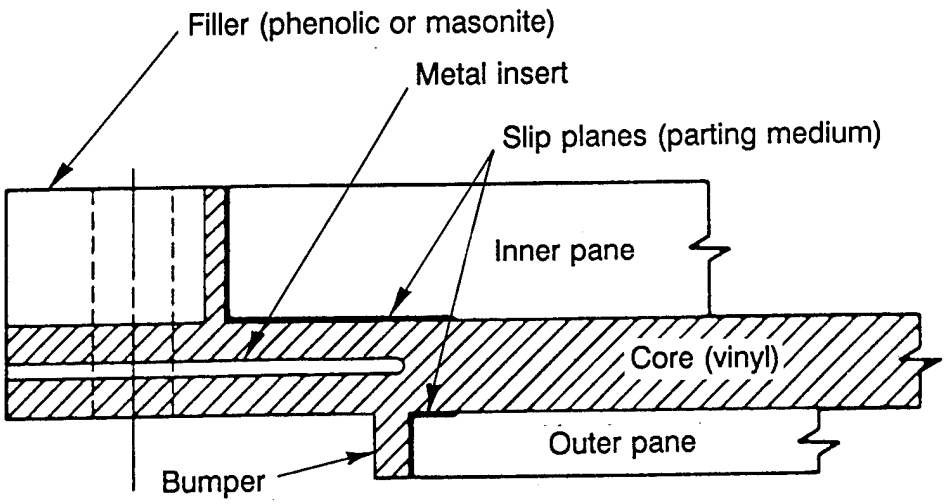


Figure 2.1 B-52 W/WS General Construction

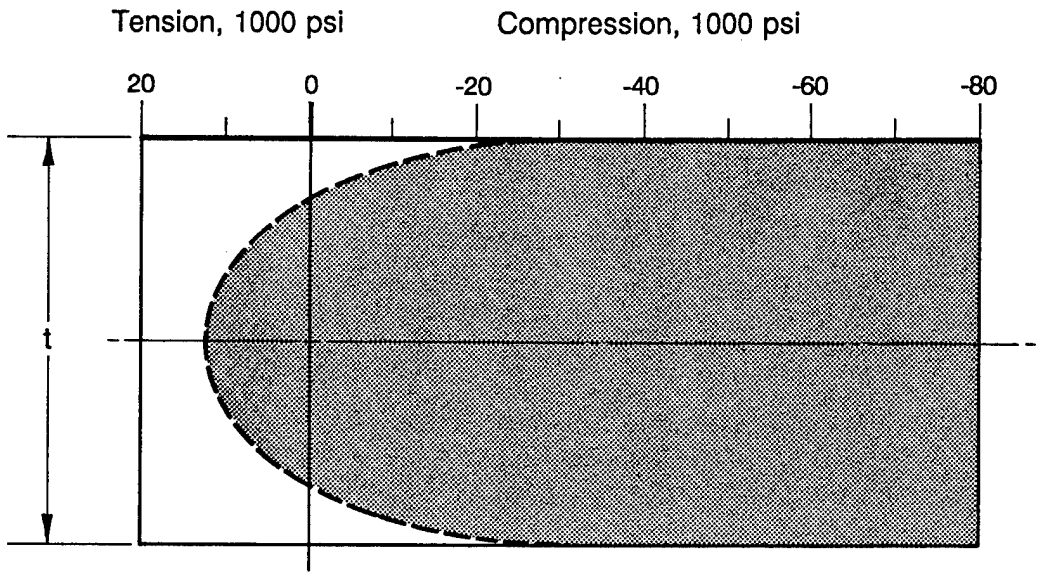


Figure 2.2 Heat Strengthened Glass Residual Stresses

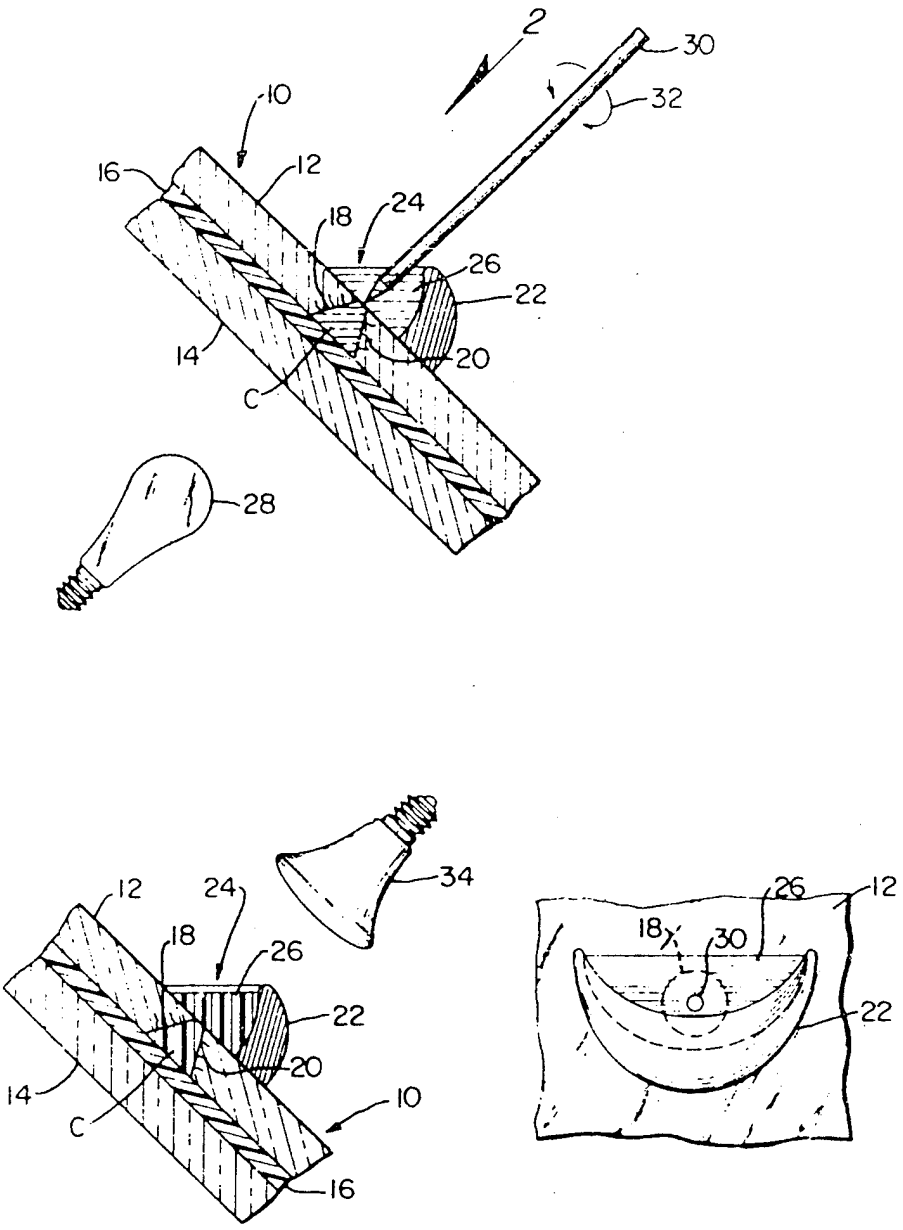


Figure 3.1 The Glass Doctor Patented Technique for Repair of Conical cracks in Laminated Glass, U.S. Patent #3,841,932

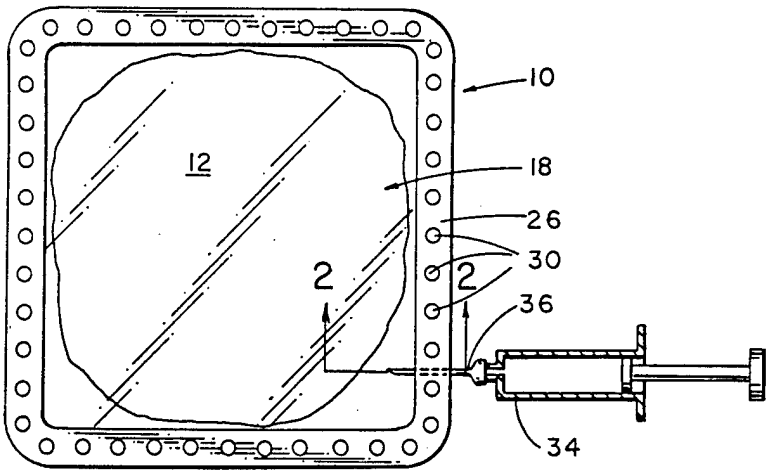


Fig. 2

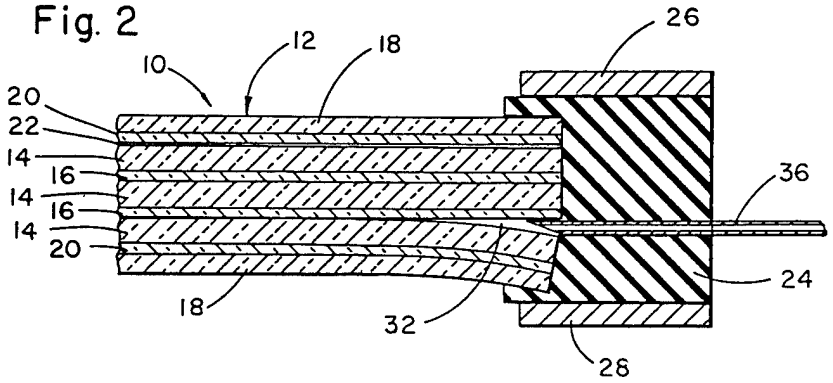


Figure 3.2 The Glass Doctor Patented Technique for Repair of Delaminations in Glass W/WS, U.S. Patent # 4,780,162

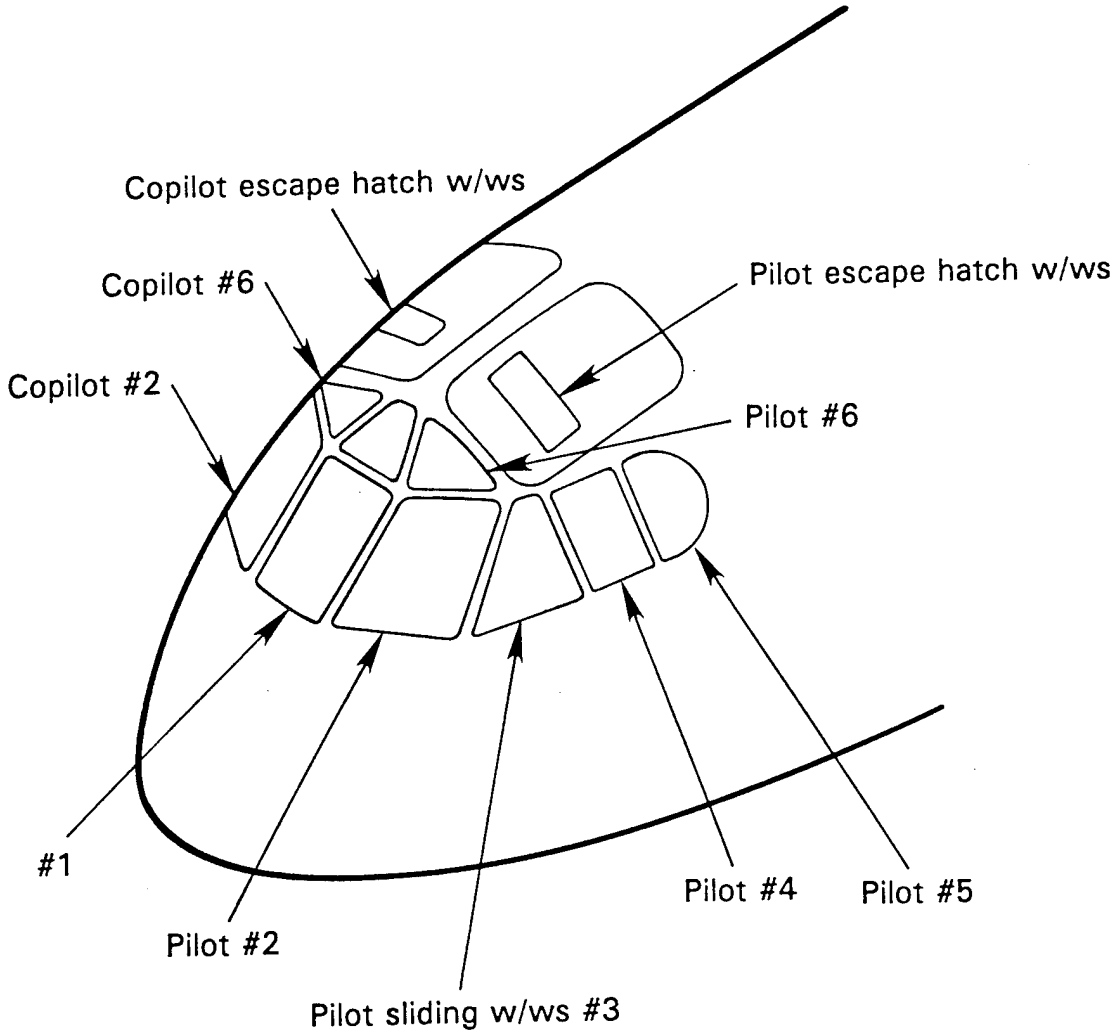


Figure 3.3 B-52 W/WS Identification

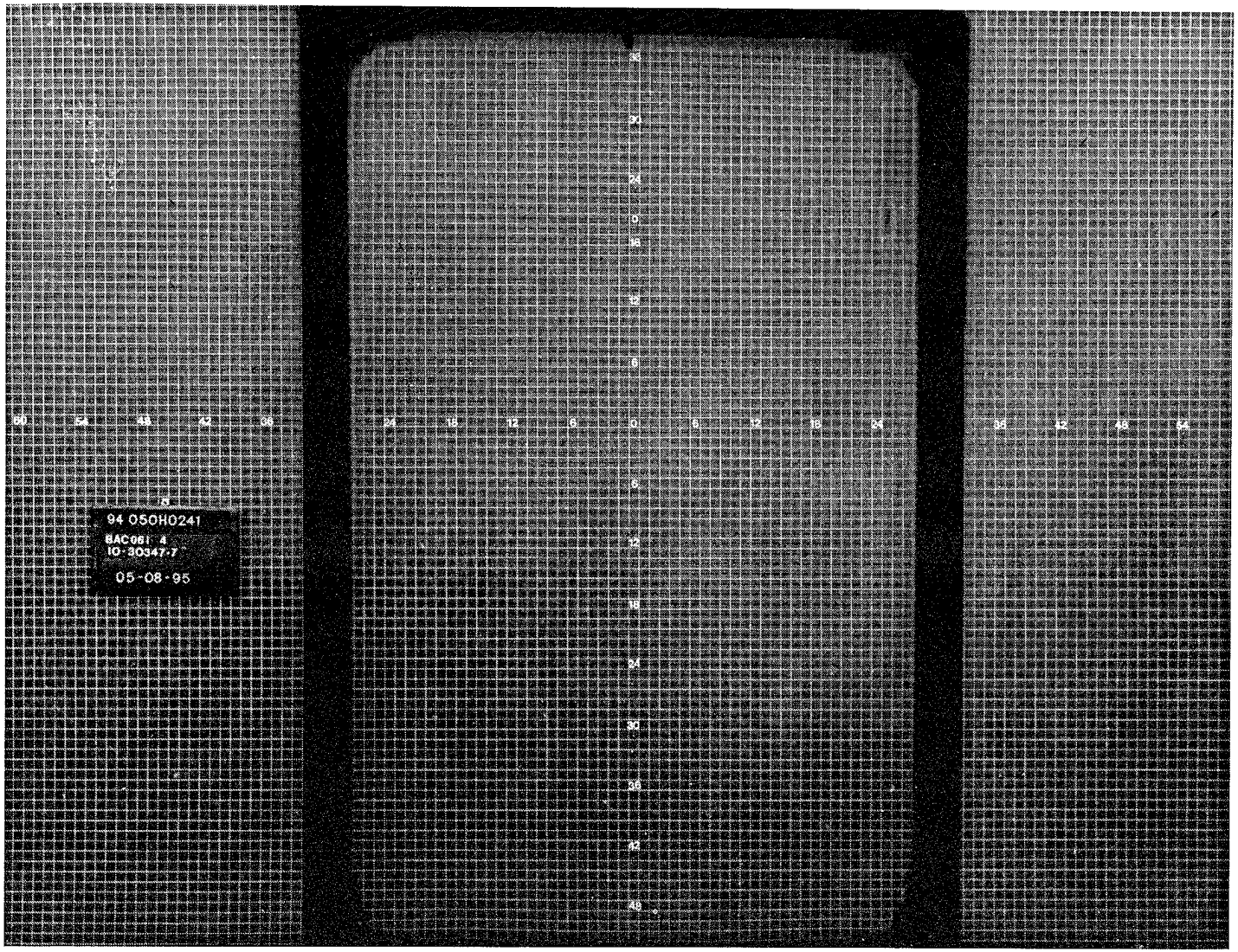


Figure 4.1 Worst B-52 #1 W/WS Optical Distortion (S/N 94-050-HO-241)

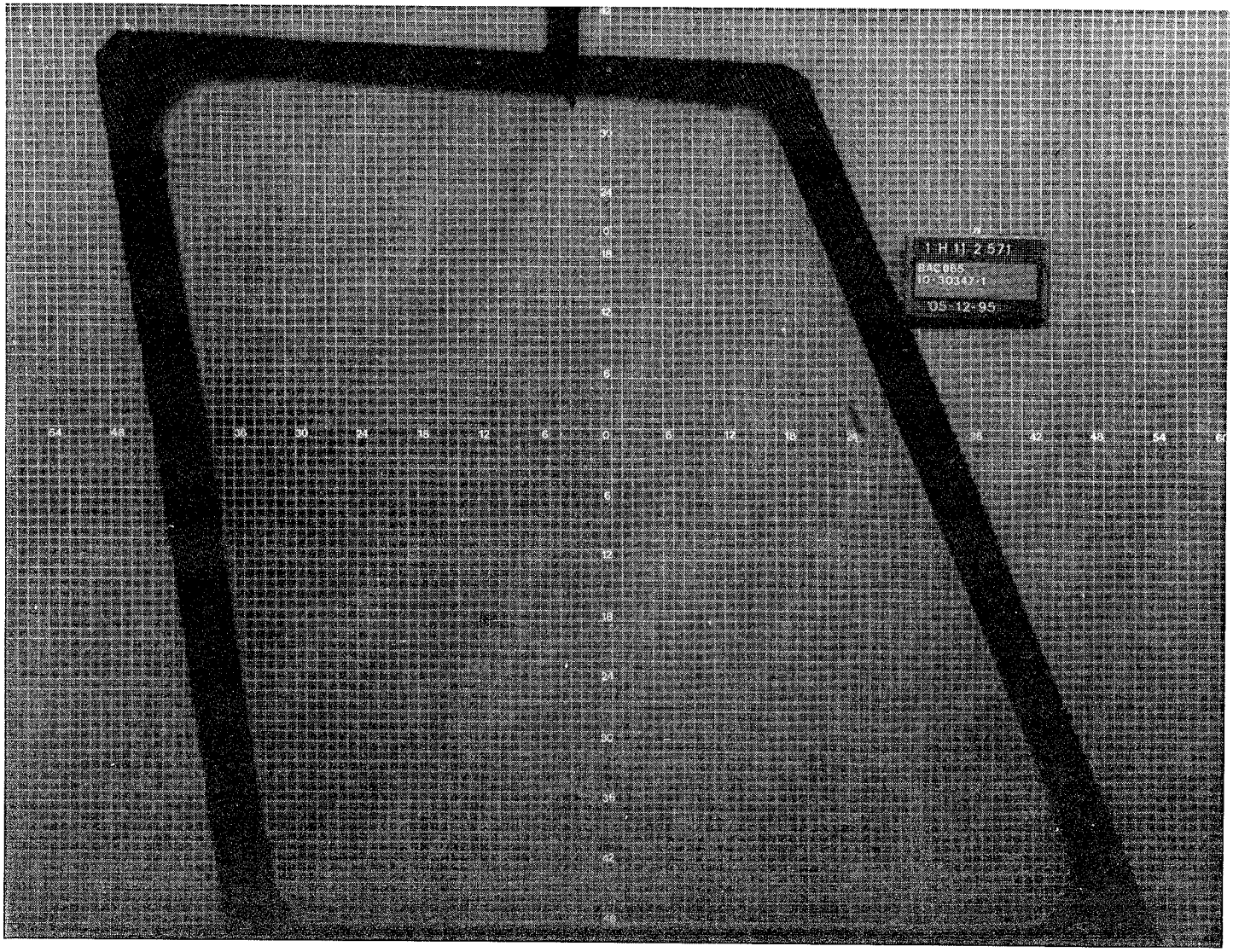


Figure 4.2 Worst B-52 #2 W/WS Optical Distortion (S/N 1-H-11-2-571)

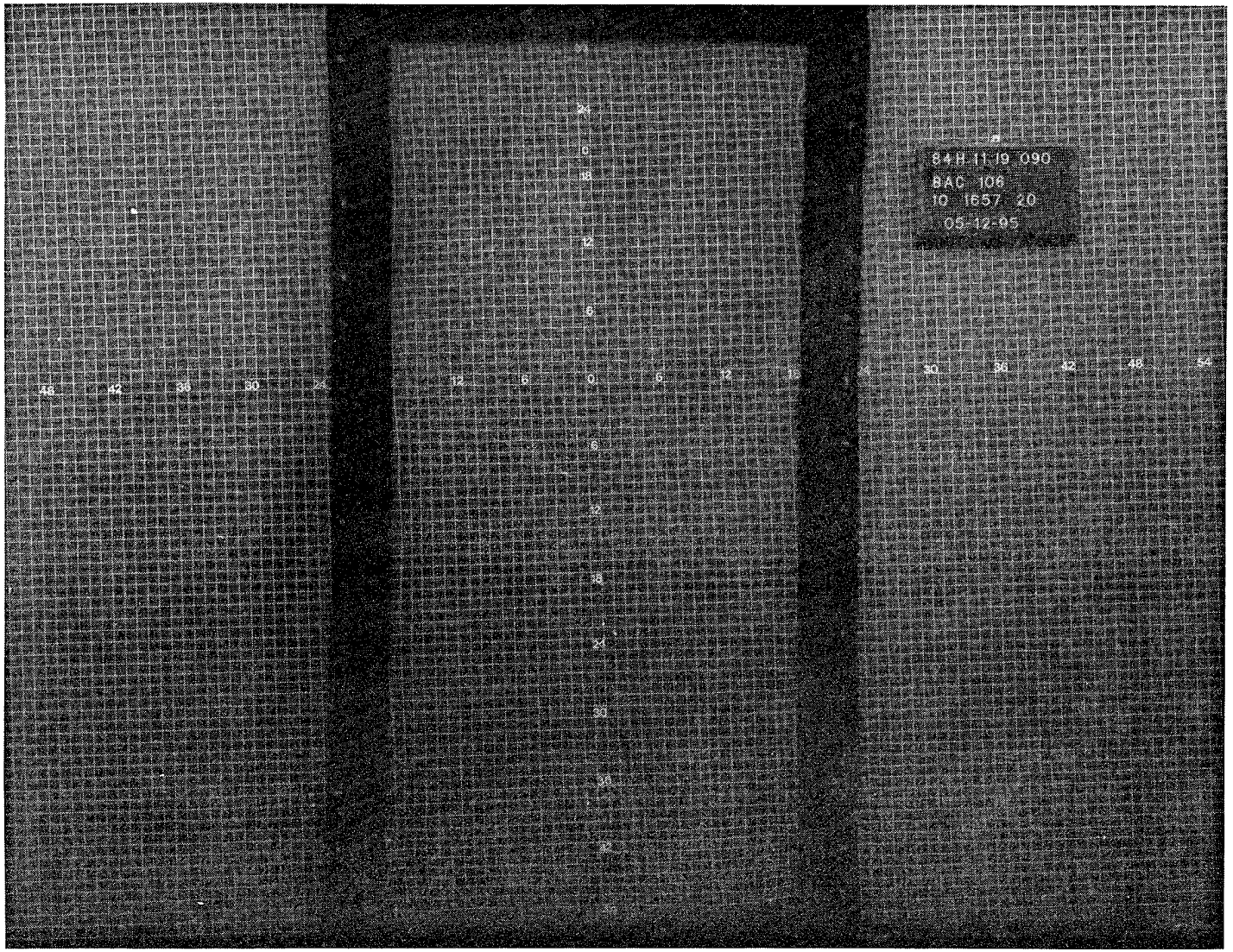


Figure 4.3 Worst B-52 Escape Hatch Optical Distortion (S/N 84-H-11-19-090)

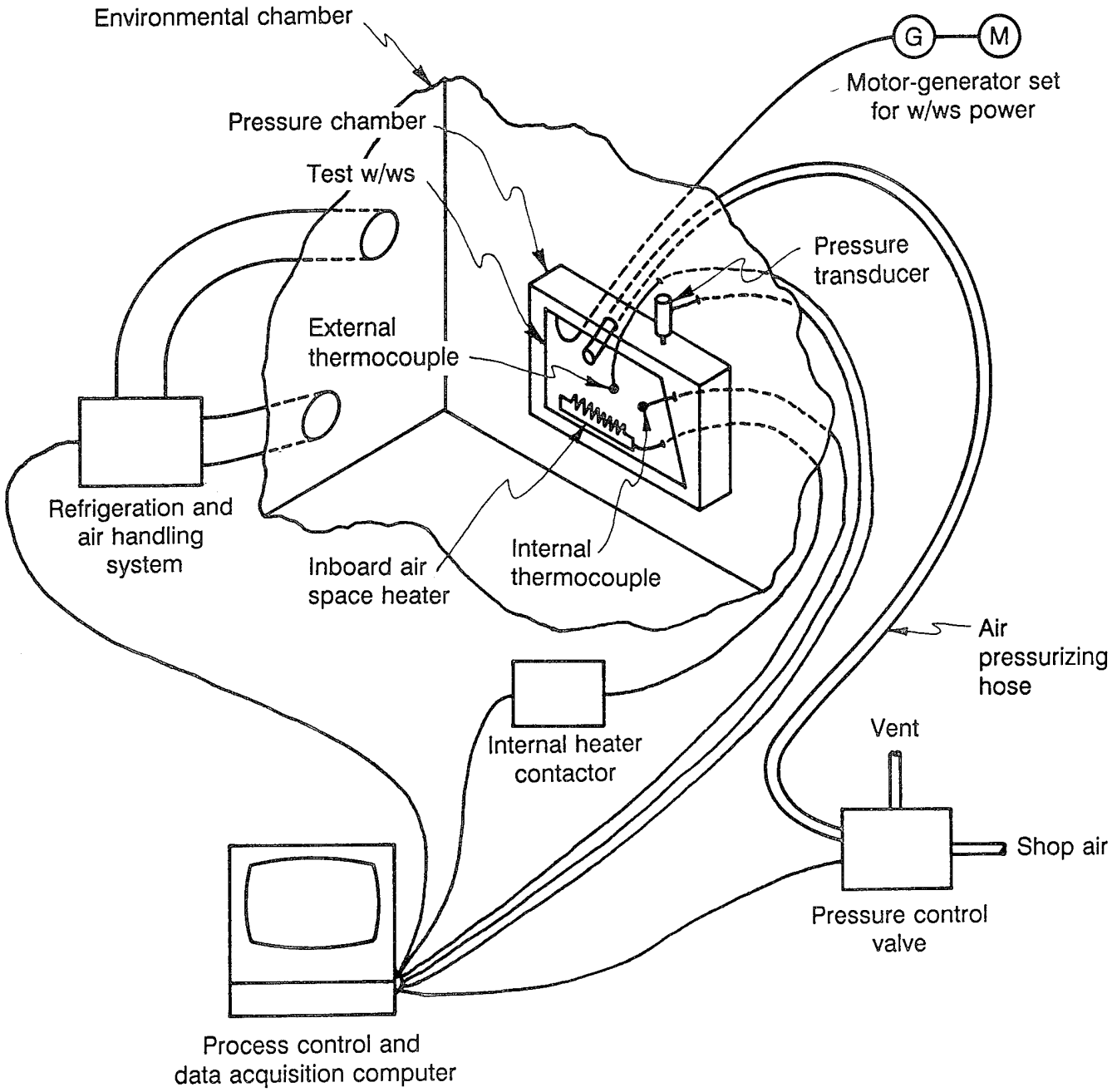


Figure 4.4 W/WS Pressure Test Facility

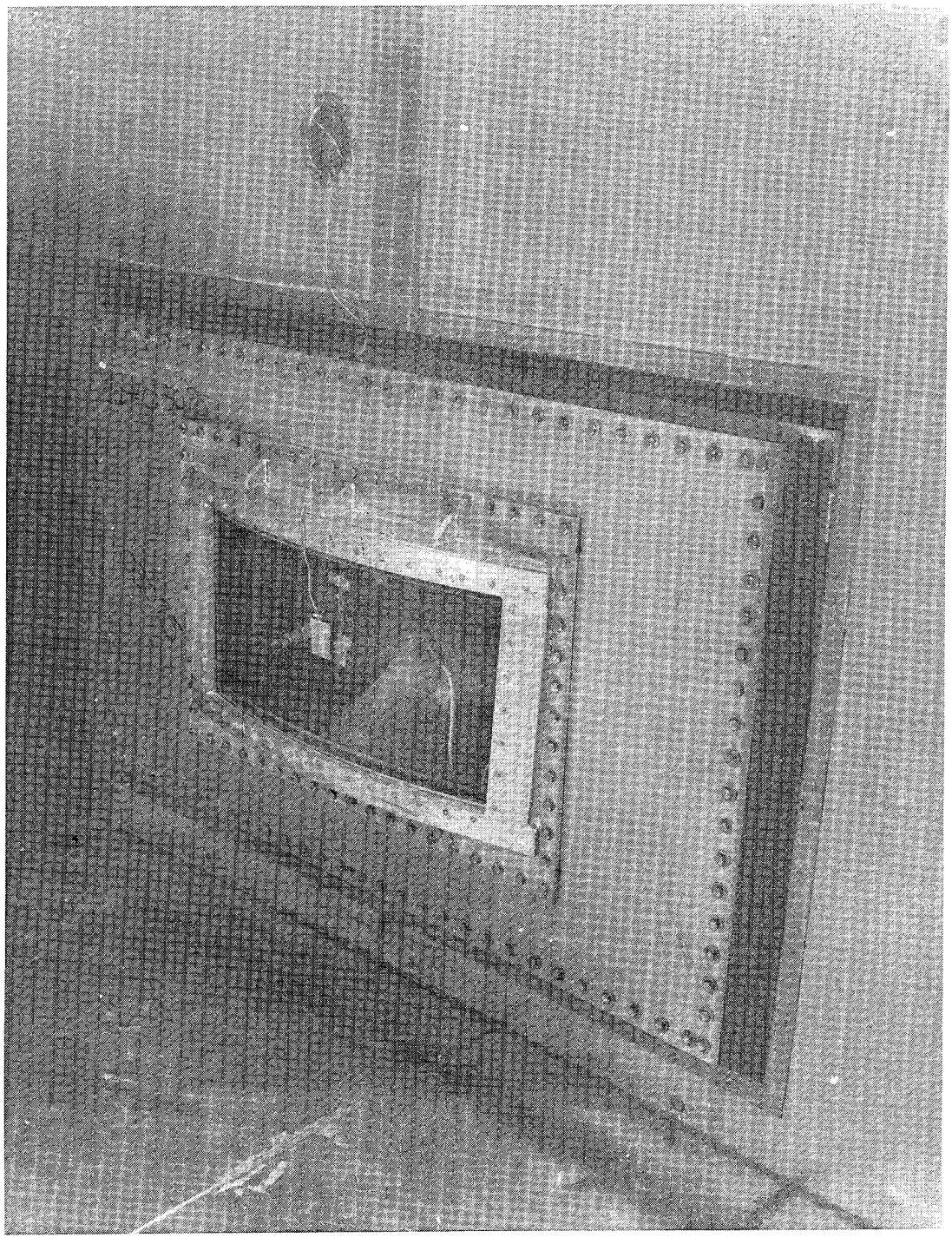


Figure 4.5 Typical Set-up for a W/WS Pressure/Thermal Cyclic Test

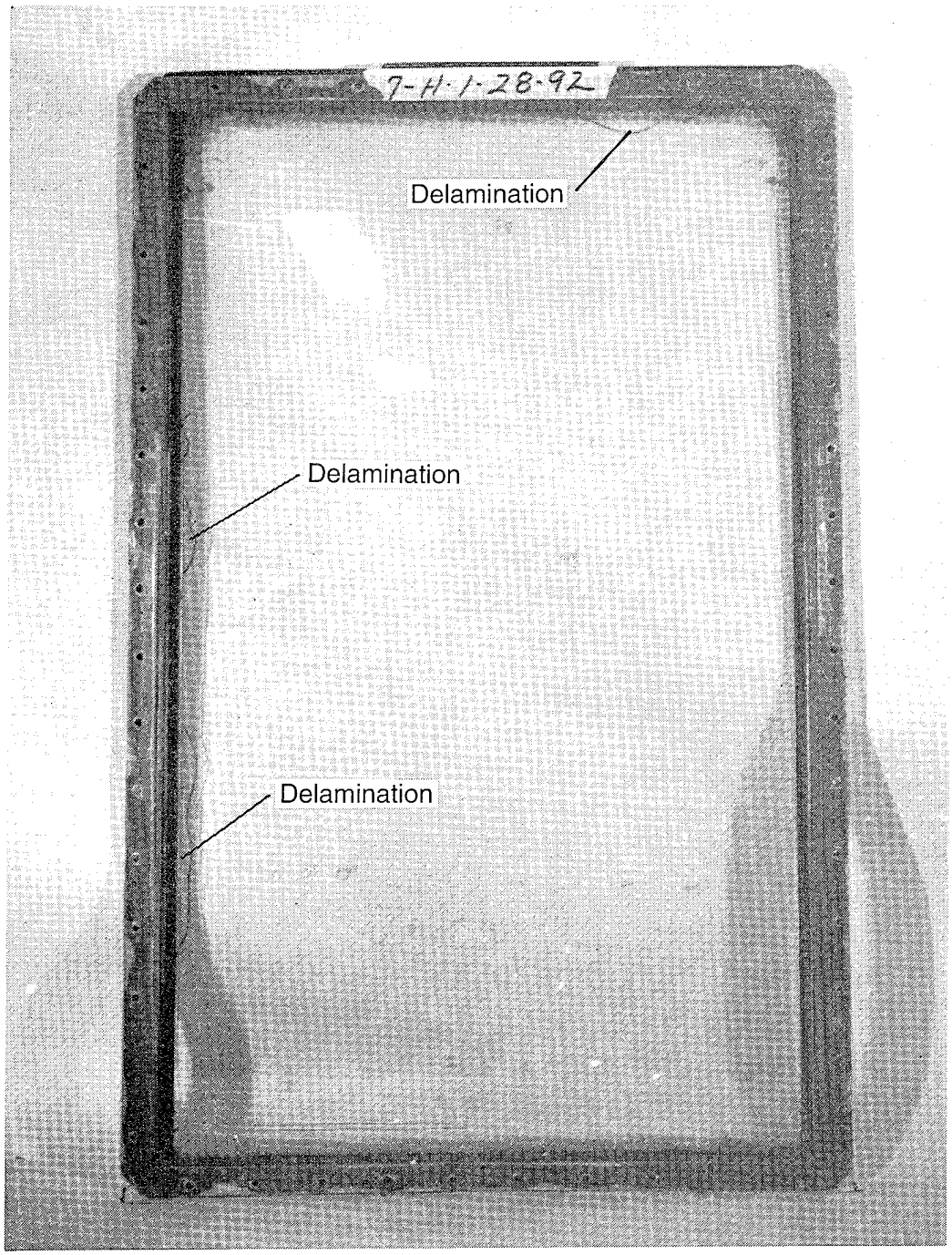


Figure 4.6 Worst B-52 #1 W/WS Delamination (S/N 7-H-1-28-92)

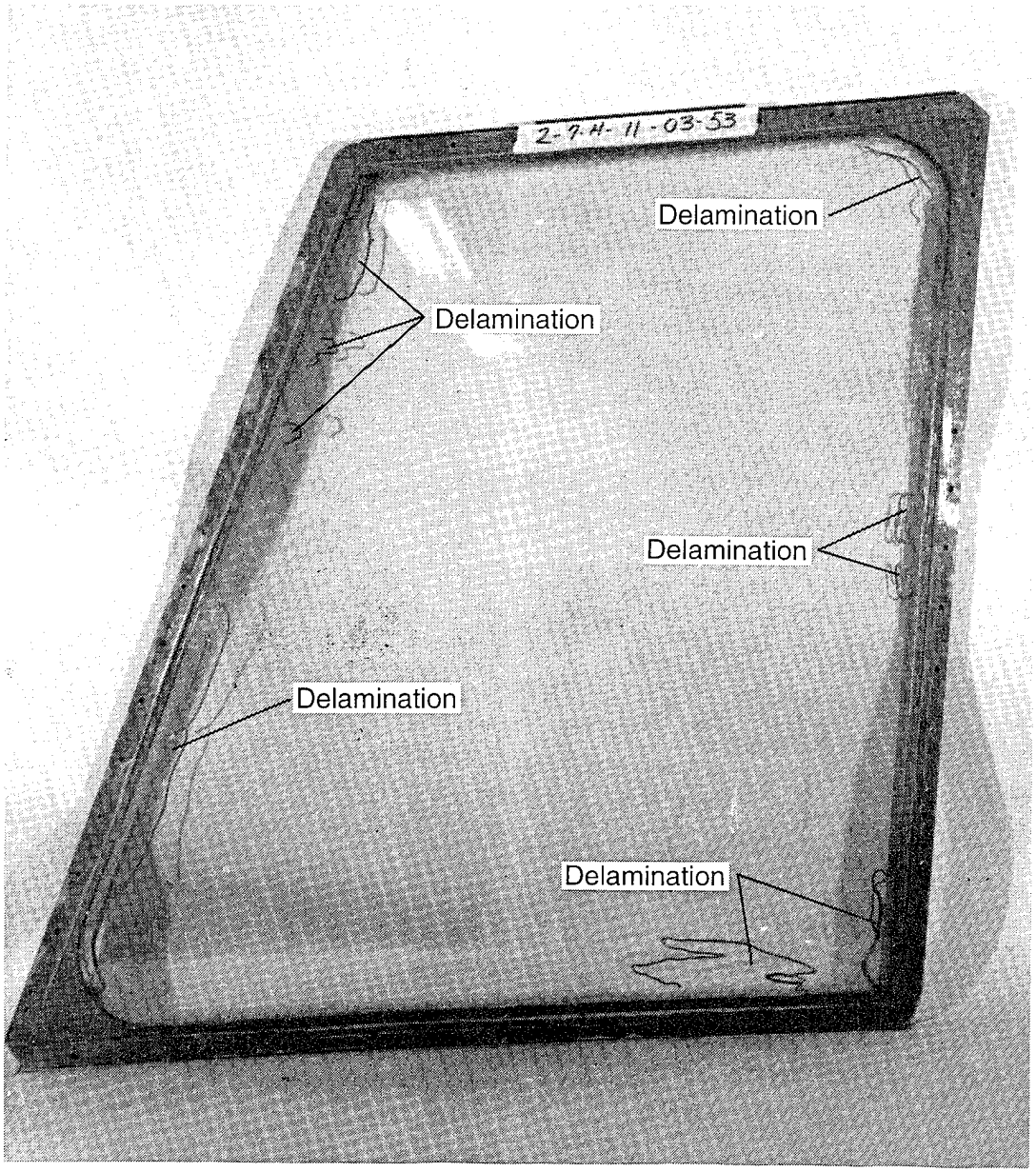


Figure 4.7 Worst B-52 #2 W/WS Delamination (S/N 7-H-11-03-53)

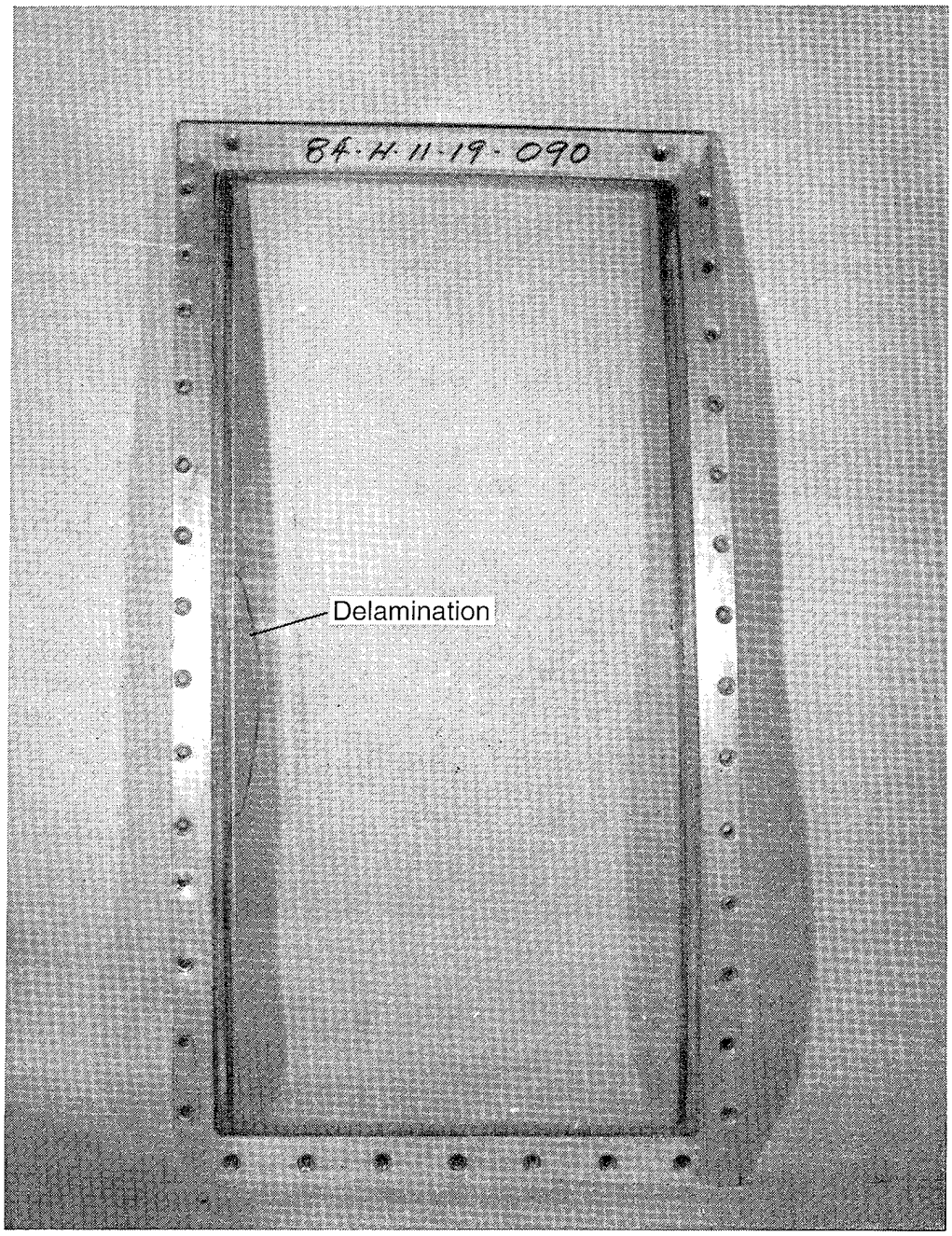


Figure 4.8 Worst B-52 Escape Hatch Delamination (S/N 84-H-11-19-090)

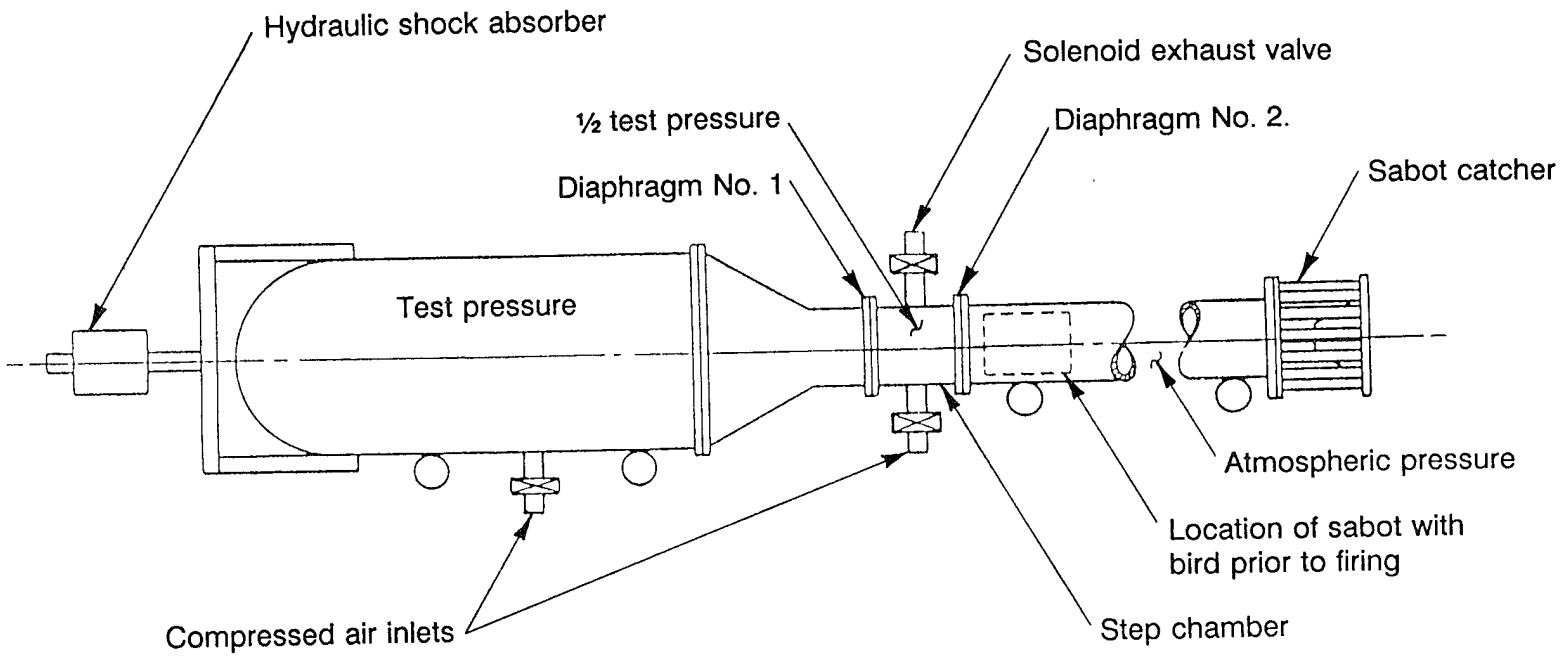


Figure 4.9 Schematic of PPG Bird Cannon

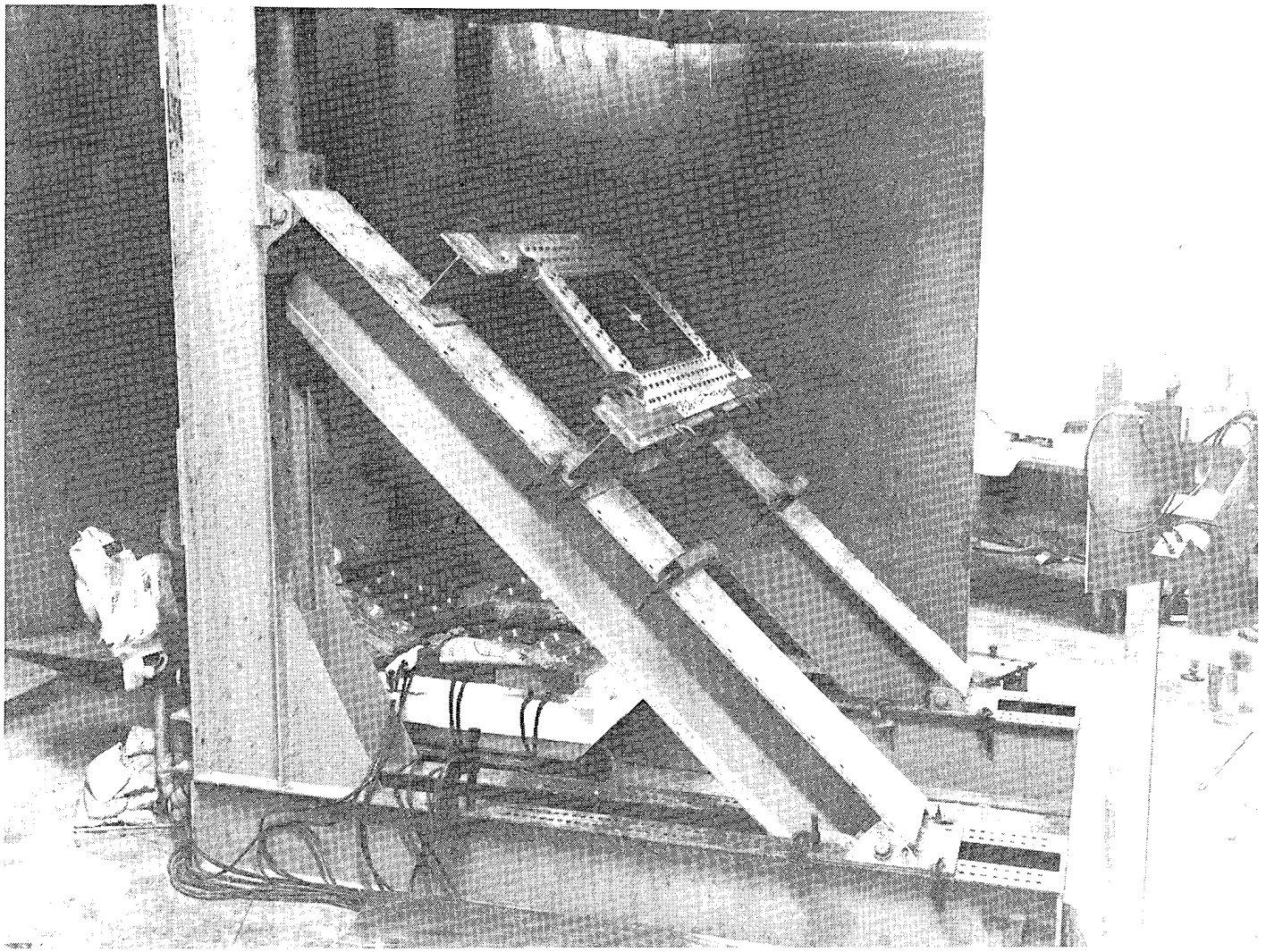


Figure 4.10 Support Frame Used for the Bird Impacts

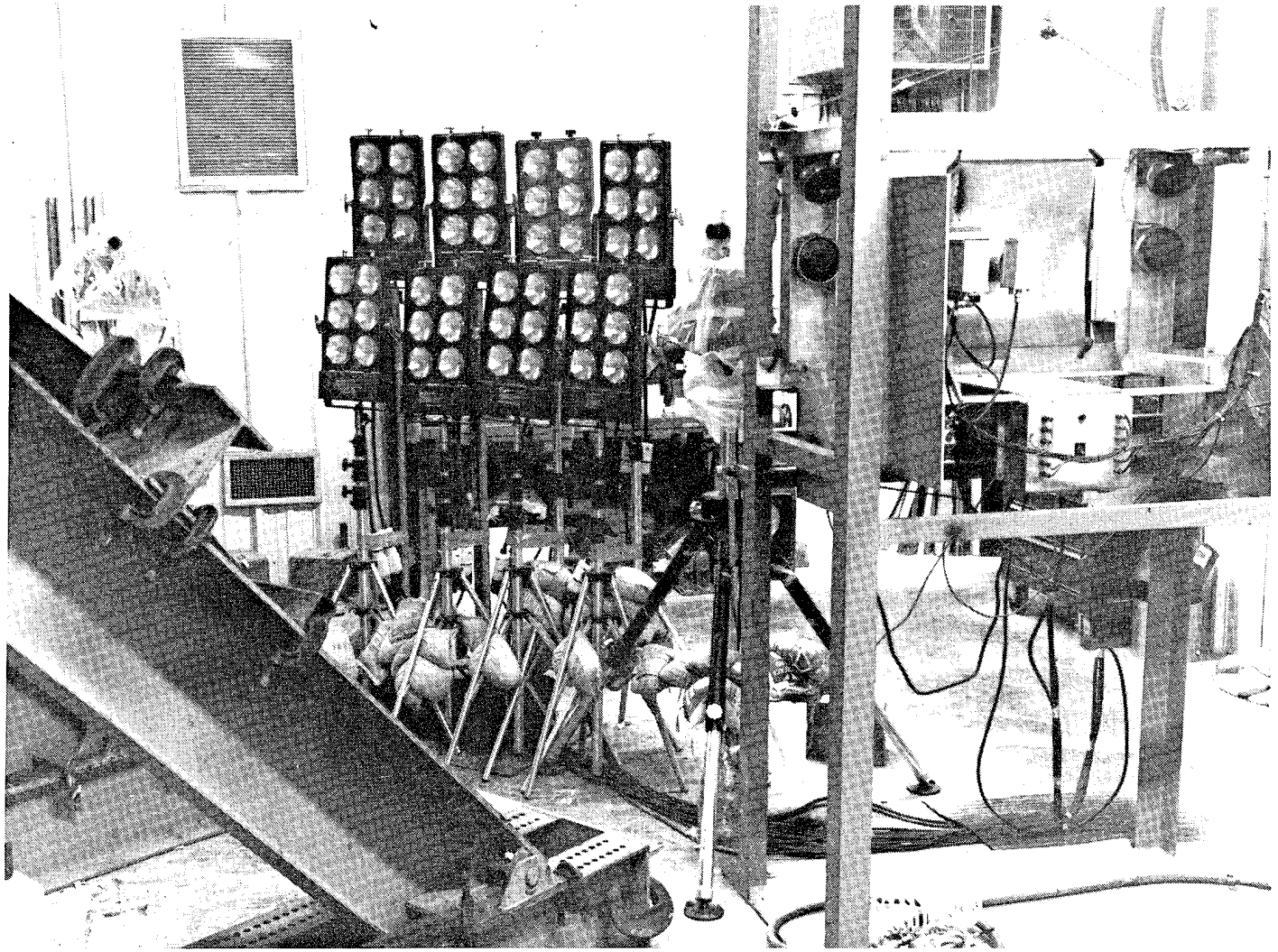


Figure 4.11 Bird Impact Test Set Up Showing Impact Velocity Timing Trap (right), High-Speed Film Equipment (center) and W/WS Support Frame (left)

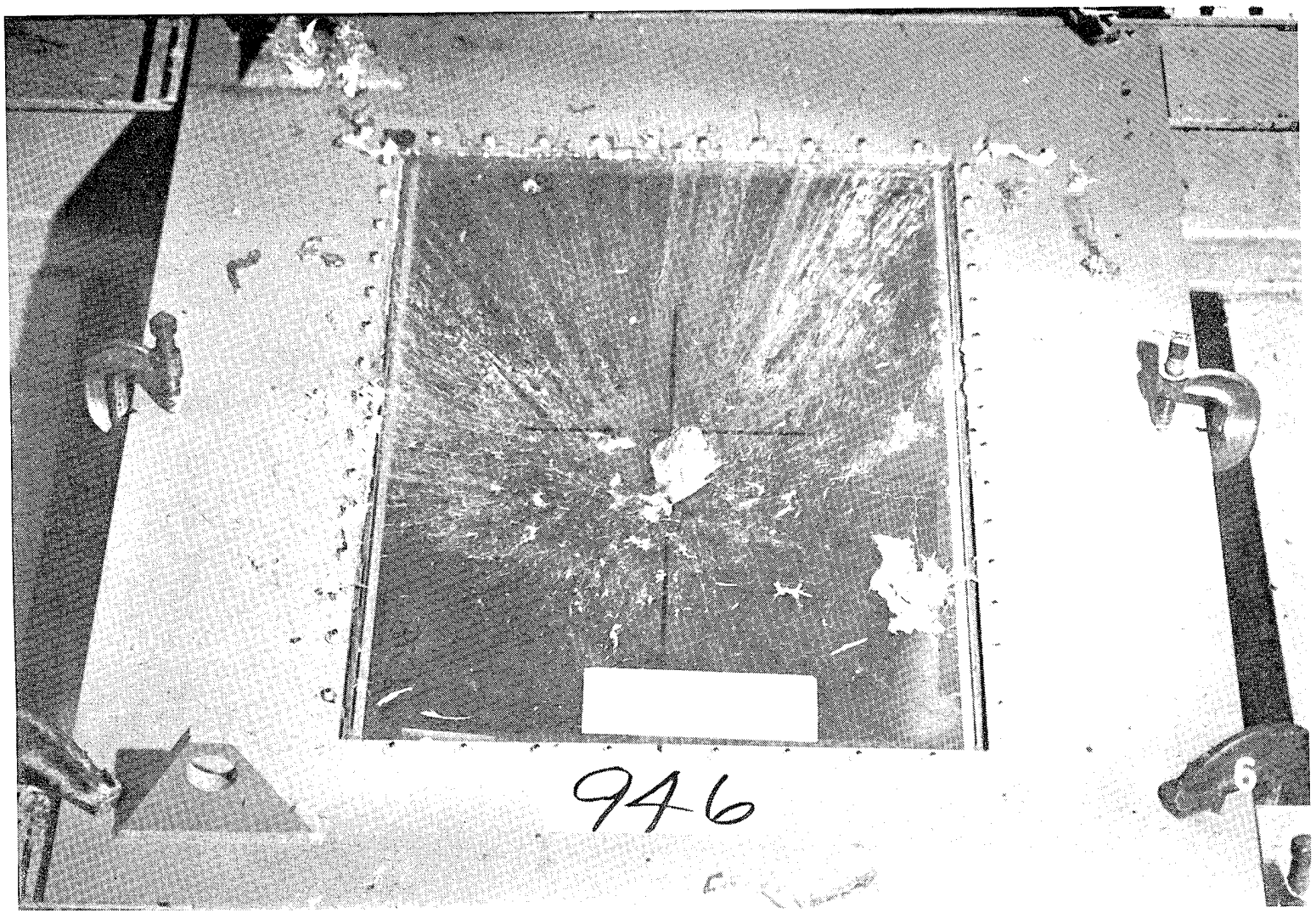


Figure 4.12 B-52 #1 W/WS Showing No Damage From a 4-Pound Bird Impact at 251 knots (S/N 87-H-11-30-749)

Figure 4.13 B-52 #1 W/WS Showing Outboard Ply Failure From a 4-Pound Bird Impact at 212 knots (S/N 86-H-03-03-298)

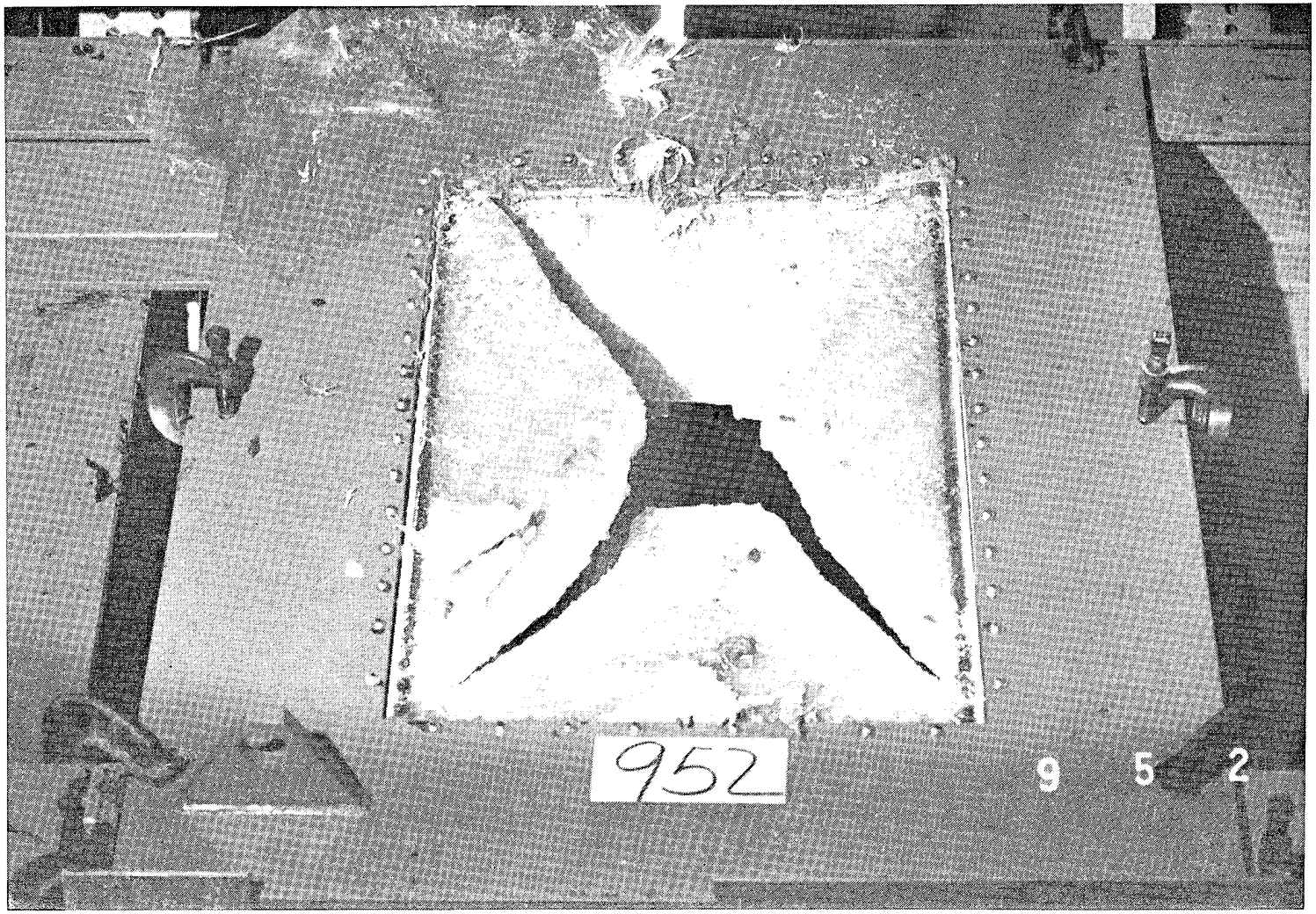


Figure 4.14 B-52 #1 W/WS Showing Worst Damage (Complete Transparency Failure) From a 4-Pound Bird Impact at 250 knots (S/N 86-H-04-28-693)

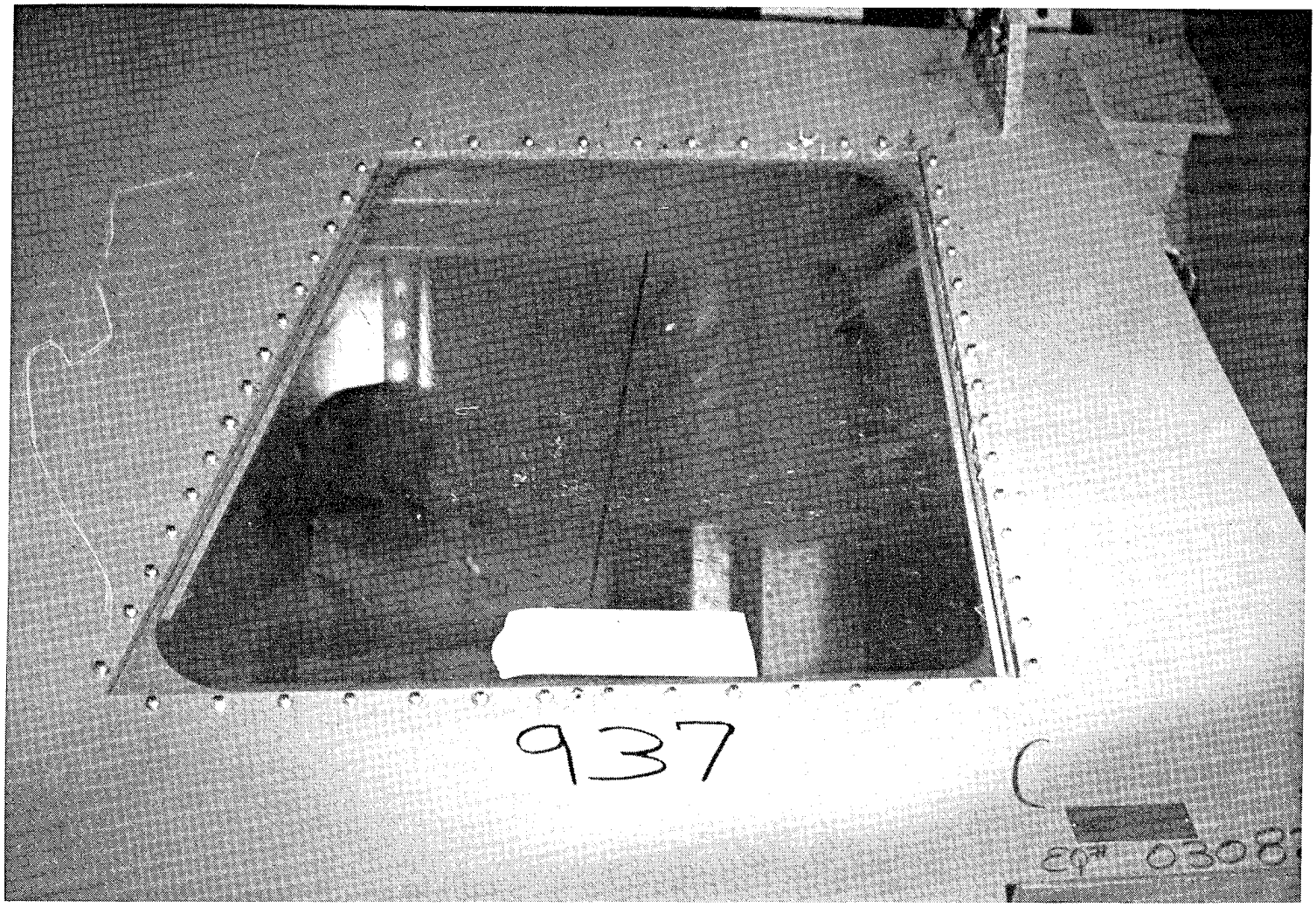


Figure 4.15 B-52 #2 W/WS Showing No Damage From a 4-Pound Bird Impact at 309 knots (S/N 92-199-HO-423)

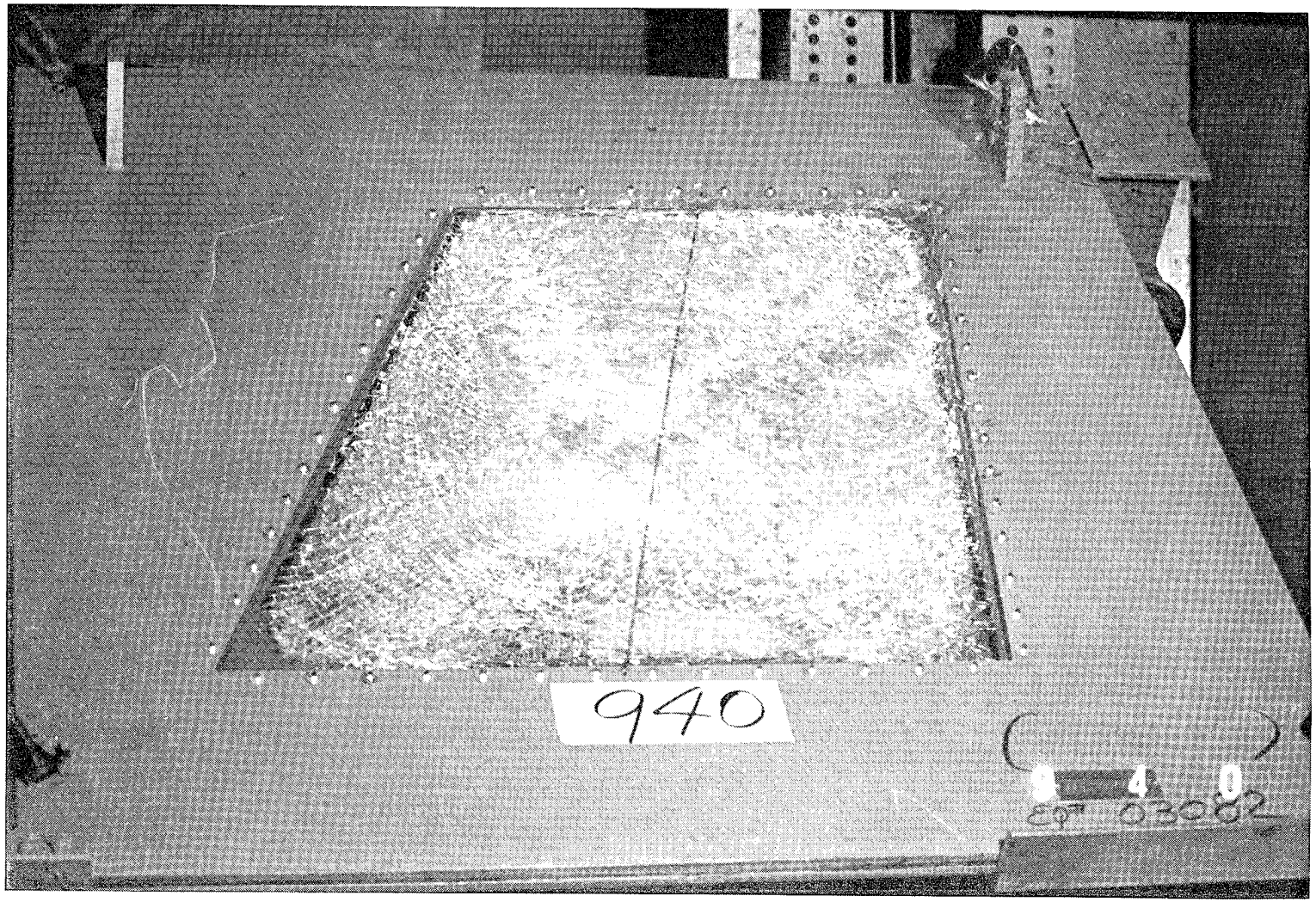


Figure 4.16 B-52 #2 W/WS Showing Outboard Ply Failure From a 4-Pound Bird Impact at 306 knots (S/N 5-H-3-04-09)

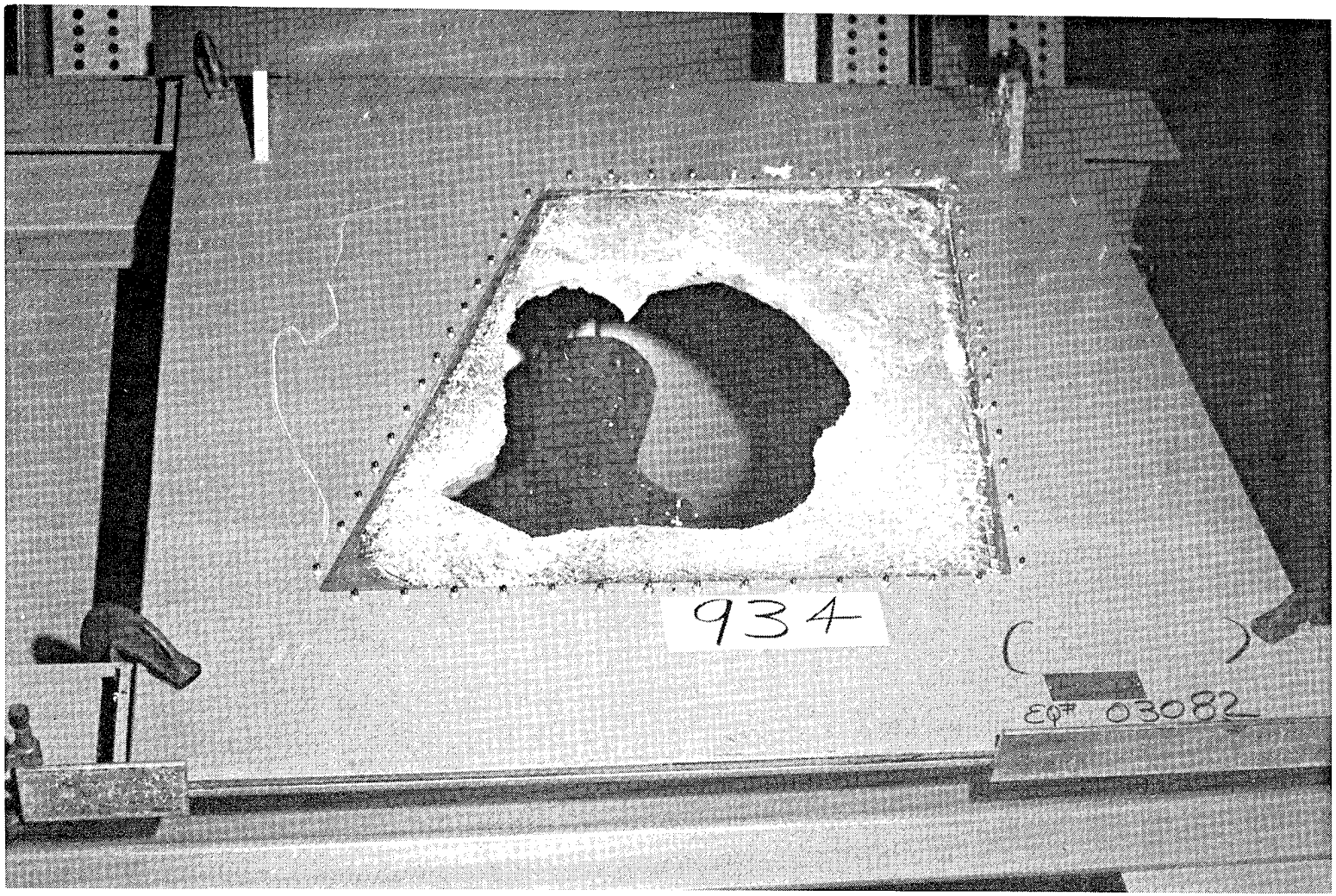


Figure 4.17 B-52 #2 W/WS Showing Worst Damage (Complete Transparency Failure) From a 4-Pound Bird Impact at 403 knots (S/N 8-H-11-20-277)

Table 3.1 B-52 W/WS Part Numbers

Designation	NSN	Part Number
#1 Center	1560-00-738-2714 FG	10-30347-7
#2 Pilot	1560-00-512-0731 FG	10-30347-1
#2 Copilot	1560-00-512-0732 FG	10-30347-2
#3 Pilot	1560-00-533-1797 FG	10-30347-3
#3 Copilot	1560-00-612-2865 FG	10-30347-4
#4 Pilot	1560-00-512-0735 FG	10-30347-5
#4 Copilot	1560-00-055-6758 FG	10-30347-6
#5 Pilot	1560-00-626-2995 FG	10-1389-37
#5 Copilot		
Escape Hatch Pilot	1560-00-630-4218 FG	10-1657-19
Escape Hatch Copilot	1560-00-652-2833 FG	10-1657-20

Table 3.2 B-52 #1 W/WS Repairs

S/N	Repair Vendor	Vendor Damage Comments	Vendor Repair Comments
7-H-1-28-92	The Glass Doctor	-	delamination, polish, seals
83-H-3-21-110		-	delamination, polish, seals
86-H-03-03-298		-	delamination, polish, seals
86-H-04-28-693		-	delamination, replacement sensor, polish, seals
87-H-11-02-614		-	delamination, polish, seals
89-116-HO-366		-	delamination, polish, seals
89-216-HO-298		-	delamination, polish, seals
83-H-3-21-109	PPG	bad bumper/seal, surface scratches, clean	remove scratches, repair bumper, clean and inspect
87-H-11-02-396		bad seal/bumper, delamination, clean	repair bumper, clean and inspect
89-H-137-HO-152		bad seal/bumper, clean	repair bumper, clean and inspect
92-288-HO-631		bad seal/bumper, surface scratches (grind & polish required), clean	distortion O.K., repair bumper, clean and inspect

Table 3.3 B-52 #2 W/WS Repairs

S/N	Repair Vendor	Vendor Damage Comments	Vendor Repair Comments
5-H-3-20-17	The Glass Doctor	-	delamination, polish, seals
7-H-11-03-53		-	delamination, polish, seals
8-H-11-20-277		-	delamination, polish, seals
8-H-11-20-436		-	delamination, polish, seals
85-H-07-15-044		-	delamination, replacement sensor, polish, seals
86-H-07-14-260		-	delamination, polish, seals
91-277-HO-574		-	delamination, polish, seals
1-H-11-2-571	PPG	delamination, bad bumper/seal, surface scratches,	polish, polishing distortion, repair bumper clean and inspect
5-H-3-04-09		bad seal/bumper, surface scratches, clean	polish, distortion OK, repair bumper, clean and inspect
86-H-05-12-588		bad bumper/seal, clean	repair bumper, clean and inspect
88-H-06-27-021		surface scratches, rubs, clean	polish, polishing distortion, repair bumper, clean and inspect

Table 3.4 B-52 Escape Hatch W/WS Repairs

S/N	Repair Vendor	Vendor Damage Comments	Vendor Repair Comments
84-H-11-19-090	The Glass Doctor	-	delamination, polish, seals
85-H-02-18-621		-	delamination, polish, seals
87-H-05-04-554		-	delamination, polish, seals
88-H-09-19-253	PPG	bad seal, clean	polish, polishing distortion, clean retainer
92-100-HO-683		bad seal, surface scratches, clean	polish, polishing distortion, clean retainer

Table 4.1 B-52 #1 W/WS General Examination Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Visual Examination	Seal	Vinyl	Comments
7-H-1-28-92	repaired	**REJ**	acc	acc	1,3be
83-H-3-21-110	repaired	**REJ**	acc	acc	2
86-H-03-03-298	repaired	acc	acc	acc	-
86-H-04-28-693	repaired	**REJ**	acc	acc	3bd
87-H-11-02-614	repaired	acc	acc	acc	-
89-116-HO-366	repaired	**REJ**	acc	acc	3be
89-216-HO-298	repaired	**REJ**	acc	acc	2,3bce
83-H-3-21-109	repaired	**REJ**	acc	acc	1,2,3abd
87-H-11-02-396	repaired	**REJ**	acc	acc	2
89-H-137-HO-152	repaired	acc	acc	acc	-
92-288-HO-631	repaired	**REJ**	acc	acc	3abf
9-H-11-19-503	not repaired	**REJ**	**REJ**	acc	2,3ab
86-H-3-17-221	not repaired	**REJ**	**REJ**	acc	3ae
87-H-11-30-749	not repaired	acc	**REJ**	acc	-
94-034-HO-742	new	acc	acc	acc	-
94-050-HO-241	new	acc	acc	acc	-

Key to Comments

1 - air in slip plane
2 - air in sensor element
3 - scratches
4 - electrical connector chipped

a - center
b - peripheral
c - light
d - numerous
e - few
f - very numerous

Table 4.2 B-52 #1 W/WS General Dimensional Measurements Test Results
(acc = acceptable, **REJ** = reject)

S/N	Type	Dimensional Check	Edge Thickness	
			min	max
7-H-1-28-92	repaired	acc	0.806	0.835
83-H-3-21-110	repaired	acc	0.832	0.864
86-H-03-03-298	repaired	acc	0.803	0.858
86-H-04-28-693	repaired	acc	0.843	0.888
87-H-11-02-614	repaired	acc	0.860	**0.895**
89-116-HO-366	repaired	acc	0.813	0.873
89-216-HO-298	repaired	acc	0.854	0.883
83-H-3-21-109	repaired	acc	0.827	0.849
87-H-11-02-396	repaired	acc	0.816	0.857
89-H-137-HO-152	repaired	acc	0.836	0.856
92-288-HO-631	repaired	acc	0.852	0.883
9-H-11-19-503	not repaired	acc	**0.790**	0.804
86-H-3-17-221	not repaired	acc	0.842	0.860
87-H-11-30-749	not repaired	acc	0.808	0.838
94-034-HO-742	new	acc	0.871	0.890
94-050-HO-241	new	acc	0.853	0.877

Table 4.3 B-52 #2 W/WS General Examination Test Results
(acc = acceptable, **REJ** = reject)

S/N	Type	Visual Examination	Vinyl	Seal	Comments
5-H-3-20-17	repaired	**REJ**	acc	acc	1,3abc
7-H-11-03-53	repaired	**REJ**	acc	acc	1,3be
8-H-11-20-277	repaired	**REJ**	acc	acc	1,3be
8-H-11-20-436(4?)	repaired	**REJ**	acc	acc	1,3abe
85-H-07-15-044	repaired	**REJ**	acc	acc	3bd
86-H-07-14-260	repaired	acc	acc	acc	-
91-277-HO-574	repaired	**REJ**	acc	acc	3be
1-H-11-2-571	repaired	**REJ**	acc	acc	2,3b3
5-H-3-04-09	repaired	**REJ**	acc	acc	1,3be
86-H-05-12-588	repaired	**REJ**	acc	acc	3b
88-H-06-27-021	repaired	**REJ**	acc	acc	3abe
1-H-11-2-572	not repaired	**REJ**	acc	**REJ**	2,3abf
84-H-6-4-131	not repaired	**REJ**	acc	**REJ**	2,3abf
86-H-11-17-342	not repaired	**REJ**	acc	**REJ**	1,3abf
92-199-HO-417	new	acc	acc	acc	-
92-199-HO-423	new	acc	acc	acc	-

Key to Comments

1 - air in slip plane
2 - air in sensor element
3 - scratches
4 - electrical connector chipped

a - center
b - peripheral
c - light
d - numerous
e - few
f - very numerous

Table 4.4 B-52 #2 W/WS Dimensional Measurements Test Results
(acc = acceptable, **REJ** = reject)

S/N	Type	Dimensional Check	Edge Thickness	
			min	max
5-H-3-20-17	repaired	acc	0.850	0.870
7-H-11-03-53	repaired	acc	0.839	0.852
8-H-11-20-277	repaired	acc	0.844	0.862
8-H-11-20-436(4?)	repaired	acc	0.830	**0.872**
85-H-07-15-044	repaired	acc	0.848	0.870
86-H-07-14-260	repaired	acc	0.847	0.854
91-277-HO-574	repaired	acc	0.852	0.872
1-H-11-2-571	repaired	acc	0.830	0.852
5-H-3-04-09	repaired	acc	0.858	0.872
86-H-05-12-588	repaired	acc	0.848	0.854
88-H-06-27-021	repaired	acc	0.830	0.844
1-H-11-2-572	not repaired	acc	0.838	0.872
84-H-6-4-131	not repaired	acc	**0.800**	0.868
86-H-11-17-342	not repaired	acc	0.820	0.856
92-199-HO-417	new	acc	0.827	0.862
92-199-HO-423	new	acc	0.830	0.862

Table 4.5 B-52 Escape Hatch W/WS General Examination Test Results
(acc = acceptable, **REJ** = reject)

S/N	Type	Visual Examination	Vinyl	Comments
84-H-11-19-090	repaired	**REJ**	acc	4
85-H-02-18-621	repaired	**REJ**	acc	3be
87-H-05-04-554	repaired	**REJ**	acc	3be
88-H-09-19-253	repaired	**REJ**	acc	3bce
92-100-HO-683	repaired	acc	acc	-
94-208-HO-581	new	acc	acc	-
94-294-HO-504	new	acc	acc	-

Key to Comments

1 - air in slip plane
2 - air in sensor element
3 - scratches
4 - electrical connector chipped

a - center
b - peripheral
c - light
d - numerous
e - few
f - very numerous

Table 4.6 B-52 Escape Hatch W/WS Dimensional Measurements Test Results
(acc = acceptable, **REJ** = reject)

S/N	Type	Dimensional Check	Edge Thickness	
			min	max
84-H-11-19-090	repaired	acc	**0.780**	0.835
85-H-02-18-621	repaired	acc	0.820	0.832
87-H-05-04-554	repaired	acc	0.790	0.840
88-H-09-19-253	repaired	acc	0.832	**0.872**
92-100-HO-683	repaired	acc	0.842	0.852
94-208-HO-581	new	acc	0.822	0.868
94-294-HO-504	new	acc	0.832	0.861

Table 4.7 B-52 #1 W/WS Basic Electrical Measurements Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Bus Resistance	Sensor Resistance	Insulation Integrity	
				bus-to-sensor	sensor-to-frame
7-H-1-28-92	repaired	acc	acc	acc	acc
83-H-3-21-110	repaired	**REJ**	acc	acc	acc
86-H-03-03-298	repaired	acc	acc	acc	acc
86-H-04-28-693	repaired	acc	acc	acc	acc
87-H-11-02-614	repaired	acc	acc	acc	acc
89-116-HO-366	repaired	acc	acc	acc	acc
89-216-HO-298	repaired	acc	acc	**REJ**	acc
83-H-3-21-109	repaired	acc	acc	acc	acc
87-H-11-02-396	repaired	acc	acc	acc	acc
89-H-137-HO-152	repaired	acc	acc	acc	acc
92-288-HO-631	repaired	acc	acc	acc	acc
9-H-11-19-503	not repaired	**REJ**	acc	acc	acc
86-H-3-17-221	not repaired	**REJ**	acc	acc	acc
87-H-11-30-749	not repaired	acc	acc	acc	**REJ**
94-034-HO-742	new	acc	acc	acc	acc
94-050-HO-241	new	acc	acc	acc	acc

Table 4.8 B-52 #2 W/WS Basic Electrical Measurements Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Bus Resistance	Sensor Resistance	Insulation Integrity	
				bus-to-sensor	sensor-to-frame
5-H-3-20-17	repaired	acc	acc	acc	acc
7-H-11-03-53	repaired	acc	acc	acc	acc
8-H-11-20-277	repaired	acc	acc	acc	acc
8-H-11-20-436(4?)	repaired	acc	acc	acc	acc
85-H-07-15-044	repaired	acc	acc	acc	acc
86-H-07-14-260	repaired	acc	acc	acc	acc
91-277-HO-574	repaired	acc	acc	acc	acc
1-H-11-2-571	repaired	acc	acc	acc	acc
5-H-3-04-09	repaired	acc	acc	acc	acc
86-H-05-12-588	repaired	acc	acc	acc	acc
88-H-06-27-021	repaired	acc	acc	acc	acc
1-H-11-2-572	not repaired	acc	acc	acc	acc
84-H-6-4-131	not repaired	acc	acc	acc	acc
86-H-11-17-342	not repaired	acc	acc	acc	acc
92-199-HO-417	new	acc	acc	acc	acc
92-199-HO-423	new	acc	acc	acc	acc

Table 4.9 B-52 Escape Hatch W/WS Basic Electrical Measurements Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Bus Resistance
84-H-11-19-090	repaired	acc
85-H-02-18-621	repaired	acc
87-H-05-04-554	repaired	acc
88-H-09-19-253	repaired	acc
92-100-HO-683	repaired	acc
94-208-HO-581	new	acc
94-294-HO-504	new	acc

Table 4.10 **B-52 #1 W/WS Heater Operation Test Results**
(acc = acceptable, **REJ** = reject)

S/N	Type	Heater Operation	Hot/Cold Spots	Heater Film Scratch Test
7-H-1-28-92	repaired	92-104° F	no	acc
83-H-3-21-110	repaired	92-108° F	no	acc
86-H-03-03-298	repaired	92-106° F	no	acc
86-H-04-28-693	repaired	92-112° F	**YES**	acc
87-H-11-02-614	repaired	96-106° F	no	acc
89-116-HO-366	repaired	92-106° F	no	acc
89-216-HO-298	repaired	94-106° F	no	acc
83-H-3-21-109	repaired	94-108° F	no	acc
87-H-11-02-396	repaired	94-104° F	no	acc
89-H-137-HO-152	repaired	94-104° F	no	acc
92-288-HO-631	repaired	92-108° F	no	acc
9-H-11-19-503	not repaired	94-108° F	no	**REJ**
86-H-3-17-221	not repaired	94-106° F	no	**REJ**
87-H-11-30-749	not repaired	94-104° F	no	acc
94-034-HO-742	new	94-106° F	no	acc
94-050-HO-241	new	94-106° F	no	acc

Table 4.11 B-52 #2 W/WS Heater Operation Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Heater Operation	Hot/Cold Spots	Heater Film Scratch Test
5-H-3-20-17	repaired	84-103° F	no	acc
7-H-11-03-53	repaired	84-105° F	no	acc
8-H-11-20-277	repaired	84-105° F	no	no test
8-H-11-20-436(4?)	repaired	84-105° F	no	acc
85-H-07-15-044	repaired	84-105° F	no	acc
86-H-07-14-260	repaired	84-103° F	no	acc
91-277-HO-574	repaired	84-97° F	no	acc
1-H-11-2-571	repaired	84-103° F	no	acc
5-H-3-04-09	repaired	84-103° F	no	acc
86-H-05-12-588	repaired	84-103° F	no	acc
88-H-06-27-021	repaired	84-107° F	no	acc
1-H-11-2-572	not repaired	84-112° F	**YES**	acc
84-H-6-4-131	not repaired	84-112° F	**YES**	acc
86-H-11-17-342	not repaired	84-105° F	no	acc
92-199-HO-417	new	84-99° F	no	acc
92-199-HO-423	new	84-99° F	no	acc

Table 4.12 B-52 Escape Hatch W/WS Heater Operation Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Heater Operation	Hot/Cold Spots	Heater Film Scratch Test
84-H-11-19-090	repaired	92-104° F	no	acc
85-H-02-18-621	repaired	94-104° F	no	acc
87-H-05-04-554	repaired	94-104° F	no	acc
88-H-09-19-253	repaired	94-104° F	no	acc
92-100-HO-683	repaired	94-106° F	no	acc
94-208-HO-581	new	94-106° F	no	acc
94-294-HO-504	new	94-108° F	no	acc

Table 4.13 **B-52 #1 W/WS Optical Performance Test Results**
(acc = acceptable, **REJ** = reject)

S/N	Type	Luminous Transmittance	Haze	Deviation	Distortion center/edge
7-H-1-28-92	repaired	acc	acc	**REJ**	none/none
83-H-3-21-110	repaired	acc	acc	acc	none/none
86-H-03-03-298	repaired	acc	acc	acc	none/*
86-H-04-28-693	repaired	acc	acc	acc	none/none
87-H-11-02-614	repaired	acc	acc	acc	none/none
89-116-HO-366	repaired	acc	acc	acc	none/none
89-216-HO-298	repaired	acc	acc	acc	none/none
83-H-3-21-109	repaired	acc	acc	acc	none/*
87-H-11-02-396	repaired	acc	acc	acc	none/none
89-H-137-HO-152	repaired	acc	acc	**REJ**	none/none
92-288-HO-631	repaired	acc	acc	acc	none/none
9-H-11-19-503	not repaired	acc	acc	**REJ**	none/*
86-H-3-17-221	not repaired	acc	acc	**REJ**	none/none
87-H-11-30-749	not repaired	acc	acc	**REJ**	none/none
94-034-HO-742	new	acc	acc	acc	none/none
94-050-HO-241	new	acc	acc	acc	none/*

* small 2- to 3-inch by 1-inch area from polishing operation

Table 4.14 B-52 #2 W/WS Optical Performance Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Luminous Transmittance	Haze	Deviation	Distortion center/edge
5-H-3-20-17	repaired	acc	acc	acc	none/none
7-H-11-03-53	repaired	acc	acc	acc	none/none
8-H-11-20-277	repaired	acc	acc	acc	none/none
8-H-11-20-436(4?)	repaired	acc	acc	acc	none/none
85-H-07-15-044	repaired	acc	acc	acc	none/*
86-H-07-14-260	repaired	acc	acc	acc	none/*
91-277-HO-574	repaired	acc	acc	acc	none/*
1-H-11-2-571	repaired	acc	acc	acc	none/1:6
5-H-3-04-09	repaired	acc	acc	acc	none/none
86-H-05-12-588	repaired	acc	acc	acc	none/*
88-H-06-27-021	repaired	acc	acc	acc	none/*
1-H-11-2-572	not repaired	acc	acc	acc	none/*
84-H-6-4-131	not repaired	acc	acc	acc	none/*
86-H-11-17-342	not repaired	acc	acc	acc	none/none
92-199-HO-417	new	acc	acc	acc	none/*
92-199-HO-423	new	acc	acc	acc	none/*

* small 2- to 3-inch by 1-inch area from polishing operation

Table 4.15 B-52 Escape Hatch W/WS Optical Performance Test Results
(acc=acceptable, **REJ**=reject)

S/N	Type	Luminous Transmittance	Haze	Deviation	Distortion center/edge
84-H-11-19-090	repaired	acc	acc	acc	none/1:3
85-H-02-18-621	repaired	acc	acc	acc	none/1:10
87-H-05-04-554	repaired	acc	acc	acc	none/1:12
88-H-09-19-253	repaired	acc	acc	acc	none/1:22
92-100-HO-683	repaired	acc	acc	acc	none/1:13
94-208-HO-581	new	acc	acc	acc	none/1:13
94-294-HO-504	new	acc	acc	acc	none/1:18

Table 4.16 Cyclic Pressure Integrity Testing Schedule for B-52 #1 AND #2 W/WS

Step	Outboard Air Temp	Inboard Air Temp	Applied Pressure	Applied Voltage	Heat Input	Maintain Conditions Until	Remarks
1	-65 F	70 F	-	-	-	temps stabilized	-
2	-65 F	70 F	-	*	-	temps stabilized	apply power
3	-65 F	70 F	-	*	*	deflections and temps stabilized	adjust air velocity so that heat input is dissipated without voltage cycling
4	-65 F	70 F	15 psi	-	-	250 cycles	1 psi/min pressure and depressure rate
5	-65 F	70 F	-	-	-	temps stabilized	remove power
6	70 F	70 F	-	-	-	temps stabilized	return to ambient conditions
7	Inspect for delamination						
8-14	Repeat Steps 1-7						

*

W/WS	W/WS Letter Code	Voltage, volts	Power, watts
#1	H1	330	2380
	H2	314	
	H3	298	
	H4	421	

W/WS	W/WS Letter Code	Voltage, volts	Power, watts
#2	H1	441	2600
	H2	421	
	H3	398	

Table 4.17 Cyclic Pressure Integrity Testing Schedule for B-52 Escape Hatch W/WS

Step	Outboard Air Temp	Inboard Air Temp	Applied Pressure	Applied Voltage	Heat Input	Maintain Conditions Until	Remarks
1	-65 F	70 F	-	-	-	temps stabilized	-
2	-65 F	70 F	-	161 V	-	temps stabilized	apply power
3	-65 F	70 F	10 psi	161 V	-	deflections stabilized	apply pressure
4	-65 F	70 F	10 psi	161 V	426 W	until deflections and temps stabilized	adjust air velocity so that heat input is dissipated without voltage cycling
5	-65 F	70 F	-	-	-	deflections stabilized	remove pressure, reduce air velocity to zero
6	-65 F	70 F	-	-	-	temps stabilized	remove power
7	70 F	70 F	-	-	-	temps stabilized	return to ambient conditions
8	Inspect for delamination						
9-48	Repeat Steps 1-8 five times, increasing the pressure applied at Steps 3 and 4 in 1 psi increments to a maximum of 15 psi						
49	-65 F	70 F	-	-	-	temps stabilized	-
50	-65 F	70 F	-	161 V	-	temps stabilized	apply power
51	-65 F	70 F	-	161 V	426 W	temps stabilized	see Step 4
52	-65 F	70 F	13 psi	161 V	426 W	30 minutes	apply pressure
53	-65 F	70 F	18.6 psi	161 V	426 W	30 minutes	add pressure increment
54	70 F	70 F	-	-	-	temps stabilized	return to ambient conditions
55	Inspect for delamination						

Table 4.18 B-52 #1 W/WS Pressure Integrity Test Results

S/N	Type	Initial Proof Pressure Test	Damage from Pressure Cycling	Final Proof Pressure Test
7-H-1-28-92	repaired	passed	modest delamination > 8" long on left side	passed
89-216-HO-298	repaired	passed	no apparent damage	passed
83-H-3-21-109	repaired	passed	slight delamination	passed
92-288-HO-631	repaired	passed	no apparent damage	passed
94-050-HO-241	new	passed	modest delamination > 8" long on left side	passed

Table 4.19 B-52 #2 W/WS Pressure Integrity Test Results

S/N	Type	Initial Proof Pressure Test	Damage from Pressure Cycling	Final Proof Pressure Test
7-H-11-03-53	repaired	passed	delamination > 3" long on all sides	passed
85-H-07-15-044	repaired	passed	delamination > 10" long on bottom and center post	passed
1-H-11-2-571	repaired	passed	delamination > 3" long on all sides	passed
86-H-05-12-588	repaired	passed	3" delamination in nose corner	passed
92-199-HO-417	new	passed	delamination < 2"' long on top and center post areas	passed

Table 4.20 B-52 Escape Hatch Pressure Integrity Test Results

S/N	Type	Initial Proof Pressure Test	Damage from Pressure Cycling	Final Proof Pressure Test
84-H-11-19-090	repaired	passed	delamination along all edges, > 3" at thermal switch location	passed
87-H-05-04-554	repaired	passed	no apparent damage	passed
88-H-09-19-253	repaired	passed	delamination along all edges	passed
92-100-HO-683	repaired	passed	no apparent damage	passed
94-294-HO-504	new	passed	no apparent damage	passed

Table 4.21 B-52 #1 W/WS Bird Impact Test Results

Test Type	Shot Number	S/N	Type	Impact Velocity (knots)	Comments
Velocity Selection	943	83-H-1-21-110	repaired	306	Both plies failed. Bird penetration.
	944	86-H-03-17-221	not repaired	206	No damage.
	945	86-H-03-03-298	repaired	212	Outboard ply broken.
	946	87-H-11-30-749	not repaired	251	No damage.
	947	9-H-11-19-503	not repaired	305	Both plies failed. Bird penetration.
Test Matrix	948	87-H-11-02-614	repaired	251	No damage.
	949	94-034-HO-742	new	248	No damage.
	950	87-H-11-02-396	repaired	248	No damage.
	951	89-H-137-HO-152	repaired	246	No damage.
	952	86-H-04-28-693	repaired	250	Both plies failed. Bird penetration.

Table 4.22 B-52 #2 W/WS Bird Impact Test Results

Test Type	Shot Number	S/N	Type	Impact Velocity (knots)	Comments
Velocity Selection	934	8-H-11-20-277	repaired	403	Both plies failed. Bird penetration.
	935	86-H-07-14-260	repaired	203	No damage.
	936	5-H-3-20-17	repaired	308	Outboard ply broken.
Test Matrix	937	92-199-HO-423	new	309	No damage.
	938	84-H-6-4-131	not repaired	312	No damage.
	939	91-277-HO-574	repaired	306	Both plies failed. 16 bolts broken.
	940	5-H-3-04-09	repaired	306	Both plies failed.
	941	88-H-06-27-021	repaired	302	Both plies failed. Bird penetration.
	942	8-H-11-20-436	repaired	303	No damage.

Table 5.1 Repair Cost Comparison Data for B-52 W/WS

Type of W/WS	Estimated Cost*		Actual Cost
	High	Low	
1	$2,046	$996	$1,000 & $996
2	$2,455	$1,300	$1,300 & $1,427
Escape Hatch	$2,046	$752	$1,200 & $752

* Based on Extremes of Estimates from NORDAM, Perkins Aircraft Services, The Glass Doctor, and PPG Industries.

Table 5.2 B-52 New W/WS Costs

Designation	NSN	Part Number	USAF Cost
#1 Center	1560-00-738-2714 FG	10-30347-7	$2,710.68
#2 Pilot	1560-00-512-0731 FG	10-30347-1	$3,308.00
#2 Copilot	1560-00-512-0732 FG	10-30347-2	
#3 Pilot	1560-00-533-1797 FG	10-30347-3	$2, 099.64
#3 Copilot	1560-00-612-2865 FG	10-30347-4	
#4 Pilot	1560-00-512-0735 FG	10-30347-5	$1,762.13
#4 Copilot	1560-00-055-6758 FG	10-30347-6	$2,379.26
#5 Pilot	1560-00-626-2995 FG	10-1389-37	$1,725.15
#5 Copilot			
Escape Hatch Pilot	1560-00-630-4218 FG	10-1657-19	$2,691.33
Escape Hatch Copilot	1560-00-652-2833 FG	10-1657-20	$2,866.10

APPENDIX A

REPAIR VENDOR AIR AGENCY CERTIFICATES

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Air Agency Certificate

Number EZ22812K

This certificate is issued to

NORDAM TRANSPARANCIES DIVISION

whose business address is

510 S. LANSING
TULSA, OKLAHOMA 74120

upon finding that its organization complies in all respects with the requirements of the Federal Aviation Regulations relating to the establishment of an Air Agency, and is empowered to operate an approved REPAIR STATION

with the following ratings:

LIMITED - SPECIALIZED SERVICE

This certificate, unless canceled, suspended, or revoked, shall continue in effect INDEFINITELY

By direction of the Administrator

Date issued:

February 21, 1990

Harold D Wright
HAROLD D. WRIGHT
ACTING MANAGER, SW-FSDO-15

This Certificate is not Transferable, AND ANY MAJOR CHANGE IN THE BASIC FACILITIES, OR IN THE LOCATION THEREOF, SHALL BE IMMEDIATELY REPORTED TO THE APPROPRIATE REGIONAL OFFICE OF THE FEDERAL AVIATION ADMINISTRATION

Any alteration of this certificate is punishable by a fine of not exceeding $1,000, or imprisonment not exceeding 3 years, or both

FAA Form 8000-4 (1-67) SUPERSEDES FAA FORM 390.

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Repair Station Operations Specifications

(Continuation)

Limitations:

The rating(s) set forth on Air Agency Certificate Number EZ22812K *is/are limited to the following:*

LIMITED RATING:

Specialized Service	Transparency inspection and repair in accordance with Aircarrier Engineering Orders, O.E.M Manuals, and NR 0101-301.

None

Delegated authorities:

Date issued or revised:

July 3, 1990

For the Administrator:

ROY G. WIEDEN
PRINCIPAL MAINTENANCE INSPECTOR
ASW-FSDO-15

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Air Agency Certificate

Number JKQR257L

This certificate is issued to
PERKINS AIRCRAFT SERVICES, INC.

whose business address is
5001 NORTH FREEWAY, SUITE B
FORT WORTH, TEXAS 76106

upon finding that its organization complies in all respects with the requirements of the Federal Aviation Regulations relating to the establishment of an Air Agency, and is empowered to operate an approved Repair Station;

with the following ratings:

LIMITED SPECIALIZED SERVICE (10-08-93)

This certificate, unless canceled, suspended, or revoked, shall continue in effect indefinitely.

By direction of the Administrator

Date issued:
May 2, 1991

Kenneth D. Robinson
Acting Manager, FTW FSDO

This Certificate is not Transferable, AND ANY MAJOR CHANGE IN THE BASIC FACILITIES, OR IN THE LOCATION THEREOF, SHALL BE IMMEDIATELY REPORTED TO THE APPROPRIATE REGIONAL OFFICE OF THE FEDERAL AVIATION ADMINISTRATION

Any alteration of this certificate is punishable by a fine of not exceeding $1,000, or imprisonment not exceeding 3 years, or both

FAA Form 8000-4 (1-67) SUPERSEDES FAA FORM 390.

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Repair Station Operations Specifications

(Continuation)

Limitations:

The rating(s) set forth on Air Agency Certificate Number JKQR257L *is/are limited to the following:*

LIMITED RATINGS:

SPECIALIZED SERVICE	Repair of aircraft windows, transparent enclosures, structural and non-structural composite panels, cores, flaps, ailerons and radomes. Above repairs will be performed in accordance with aircraft manufacturer's repair procedures, air carrier approved instructions and Perkins Aircraft Services, Inc., Process Specification PPS0001, Revision A, dated 09-15-93, as revised.

Delegated authorities: NONE

Date issued or revised:

October 8, 1993

For the Administrator:

Standley H. Cobb

PMI, FTW FSDO

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Air Agency Certificate

Number OX4R430M

This certificate is issued to
THE GLASS DOCTOR

whose business address is
2390 26th AVENUE NORTH
St. Petersburg, Florida 33713

upon finding that its organization complies in all respects with the requirements of the Federal Aviation Regulations relating to the establishment of an Air Agency, and is empowered to operate an approved REPAIR STATION

with the following ratings:
LIMITED - SPECIALIZED SERVICE

This certificate, unless canceled, suspended, or revoked, shall continue in effect INDEFINITELY

By direction of the Administrator

Date issued:
September 27, 1979
Replacement May 1, 1990

William J. Truebe, Manager
North Florida FSDO-15

This Certificate is not Transferable, AND ANY MAJOR CHANGE IN THE BASIC FACILITIES, OR IN THE LOCATION THEREOF, SHALL BE IMMEDIATELY REPORTED TO THE APPROPRIATE REGIONAL OFFICE OF THE FEDERAL AVIATION ADMINISTRATION

Any alteration of this certificate is punishable by a fine of not exceeding $1,000, or imprisonment not exceeding 3 years, or both

FAA Form 8000-4 (1-67) SUPERSEDES FAA FORM 390.

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Repair Station Operations Specifications

(Continuation)

Limitations:

The rating(s) set forth on Air Agency Certificate Number OX4R430M *is/are limited to the following:*

LIMITED RATINGS:

SPECIALIZED SERVICE - Refurbish and repair aircraft plastic and glass windows, windshields, canopies, navigation light lenses, and other miscellaneous small transparencies, including nicks, chips, delamination, electrical busses and temperature sensor installation.

All inspections and rework will be accomplished in accordance with the following data as applicable to the unit being worked.

Aircraft Manufacturer's Maintenance Manuals/ Instruction.

FAA Approved process Specification, #1979 Cabin and Cockpit Windows dated 12-31-84 (as amended).

Air Carrier's Approved Specifications.

FAA Advisory Circular 43.13-1A, Acceptable Methods, Techniques, and Practices, Chapter 9, Windshields, Enclosures and Exits.

Delegated authorities: NONE

Date issued or revised:

May 1, 1990

For the Administrator:

Kenneth S. Crockett
Principal Maintenance Inspector

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Air Agency Certificate

Number IL4R262M

This certificate is issued to

PPG INDUSTRIES, INC.

whose business address is

1719 HIGHWAY 72 EAST
HUNTSVILLE, ALABAMA

upon finding that its organization complies in all respects with the requirements of the Federal Aviation Regulations relating to the establishment of an Air Agency, and is empowered to operate an approved REPAIR STATION

with the following ratings:

SPECIALIZED SERVICE

This certificate, unless canceled, suspended, or revoked, shall continue in effect INDEFINITELY

By direction of the Administrator

Date issued:

AUGUST 1, 1973

REISSUED: JULY 9, 1990

JOHNNY R. HARDY
MANAGER, SO-FSDO-09

This Certificate is not Transferable, AND ANY MAJOR CHANGE IN THE BASIC FACILITIES, OR IN THE LOCATION THEREOF, SHALL BE IMMEDIATELY REPORTED TO THE APPROPRIATE REGIONAL OFFICE OF THE FEDERAL AVIATION ADMINISTRATION

Any alteration of this certificate is punishable by a fine of not exceeding $1,000, or imprisonment not exceeding 3 years, or both

FAA Form 8000-4 (1-67) SUPERSEDES FAA FORM 390.

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Repair Station Operations Specifications

(Continuation)

Limitations:

The rating(s) set forth on Air Agency Certificate Number IL4R262M *is/are limited to the following:*

LIMITED RATING:

SPECIALIZED SERVICE: REPAIR AND REWORK AIRCRAFT WINDSHIELD IN ACCORDANCE WITH MANUFACTURERS' CURRENT TECHNICAL DATA OR OTHER PROCEDURES ACCEPTABLE TO THE ADMINISTRATOR

Delegated authorities: NONE

Date issued or revised:

MARCH 10, 1994

For the Administrator:

Gary L. Soldwisch

GARY L. SOLDWISCH
PRINCIPAL AIRWORTHINESS INSPECTOR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Air Agency Certificate

Number P9AR279J

This certificate is issued to

PILKINGTON AEROSPACE INC.

whose business address is

12122 WESTERN AVE.
GARDEN GROVE, CA 92641-2990

upon finding that its organization complies in all respects with the requirements of the Federal Aviation Regulations relating to the establishment of an Air Agency; and is empowered to operate an approved REPAIR STATION

with the following ratings:

LIMITED AIRFRAME

This certificate, unless canceled, suspended, or revoked, shall continue in effect INDEFINITELY.

By direction of the Administrator

Date issued:

September 20, 1993

for Al Toll
Manager

This Certificate is not Transferable, AND ANY MAJOR CHANGE IN THE BASIC FACILITIES, OR IN THE LOCATION THEREOF, SHALL BE IMMEDIATELY REPORTED TO THE APPROPRIATE REGIONAL OFFICE OF THE FEDERAL AVIATION ADMINISTRATION

Any alteration of this certificate is punishable by a fine of not exceeding $1,000, or imprisonment not exceeding 3 years, or both

Form 8000-4 (1-67) SUPERSEDES FAA FORM 390.

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Repair Station Operations Specifications

(Continuation)

Limitations:

The rating(s) set forth on the Air Agency Certificate Number P9AR279J *is/are limited to the following:*

LIMITED RATING:

AIRFRAME — REPAIR AND RESTORATION OF AIRCRAFT WINDOWS FOR BOEING, MCDONNELL DOUGLAS, AIRBUS INDUSTRIES, SAAB, LOCKHEED, FAIRCHILD AND BRITISH AEROSPACE, ALL MODELS.

Delegated authorities: NONE

Date issued or amended:

September 20, 1993

For the Administrator:

Edward C. Mays
Aviation Safety Inspector, Airworthi

FAA Form 8000-4-1 (1-79)

FORMERLY FAA FORM 390

APPENDIX B

B-52 W/WS TEST PLAN

MASTER TEST PLAN/PROGRAM TEST PLAN

Data Item A046

on

DEVELOPMENT OF REPAIR PROCESSES AND SOURCES FOR B-52 AIRCRAFT WINDOWS/WINDSHIELDS

to

TINKER AIR FORCE BASE
Oklahoma City, OK

July 13, 1994

by

R. Olson

Battelle
. . . Putting Technology To Work

MASTER TEST PLAN/PROGRAM TEST PLAN

on

DEVELOPMENT OF REPAIR PROCESSES AND SOURCES FOR B-52 AIRCRAFT WINDOWS/WINDSHIELDS

to

TINKER AIR FORCE BASE

from

BATTELLE

July 13, 1994

1.0 INTRODUCTION

The following tests have been designed to establish that the structural integrity of repaired B-52 aircraft windows/windshields (W/WS) is adequate to ensure safety and reliability. The repaired W/WS shall be repaired by two FAA certified repair stations using FAA-approved methods. The repairs performed on the prototype W/WS are the exact repairs currently performed on similar commercial W/WS. A Defects Catalog has been prepared as part of this program which documents the prototype identification information and the type of damage observed at the time of selection. The test procedures, for the most part, are consistent with the original design specifications for the W/WS.

2.0 APPLICABLE DOCUMENTS

The documents listed in this section are used to establish the technical requirements and test procedures.

B-52 Technical Orders

1B-52G-4, Section II	Group Assembly Parts List
1B-52B-2-2, Section XI	Fuselage Windows
1B-52G-2-2JG-10	Fuselage Windows
1B-52G-2-2MS-1	Maintenance of the Fuselage Windows

B-52 W/WS Design Specifications

10-30347	Windshield Assembly Pilot and Copilot (#1 & #2 W/WS)
D10-1657	B-52 Specification for Window Assembly Electrically Heated (Escape Hatch W/WS)
10-1675	Specification for Sensing Element Windshield Temperature

B-52 W/WS Drawings

35-18786	Dimension & Arrangement Requirements, Windshield Assy, No 1
35-18783	Dimension and Arrangement Requirements, Windshield Assy, No 2 LH & RH
10-1657	Window Assembly Electrically Heated (Escape Hatch W/WS)

General Specifications

ASTM F 330-89	Bird Impact Test Specification
ASTM D 1003-92	Haze and Luminous Transmittance Specification
MIL-G-25871B	Glass, Laminated, Aircraft Glazing

3.0 TEST PROGRAM CONSIDERATIONS

3.1 Window Failure Criteria

The following criteria will be used to identify failure for the test prototypes as tested per applicable Structural Integrity tests. Any failure of the W/WS to maintain structural integrity is considered a failure. Additional failure criteria are discussed in the specific test, as applicable. Non-compliant test results for nonstructural parameters will be noted, but will not disqualify the prototype from further structural testing.

Inner/Outer Glass Pane:

- cracks or delaminations of any kind
- anything that impairs visibility

Middle Vinyl Core:

- cracks of any kind
- bubbles
- discoloring
- anything that impairs visibility

Nonstructural

- damaged bus bar
- cracks in vinyl or rubber bumper
- hot spots or uneven heating
- low or no heat output.

3.2 Test Sample Selection and Sources

Four sources of test W/WS will be used in this program:

- new
- repair vendor # 1
- repair vendor # 2
- unrepaired.

These sources will supply to the test program a set of W/WS consisting of the following:

	Number of Prototypes		
Type of W/WS	Repair Vendor	New W/WS	Unrepaired
#1	4	2	up to 5
#2	4	2	up to 5
Escape Hatch	2	2	0
	10 total per vendor 20 total for program	6 total	up to 10 total

3.3 Test Plan Design

The testing protocol for this program is presented in Figure 1. The test plan will be validated with new W/WS. As appropriate, unrepaired W/WS will be used to pre-qualify some of the test procedures. Modifications to the test plan will be made in this phase to correct any testing problems encountered. An acceptable test protocol once established will then be applied without modification to the repaired prototypes. Within the constraints of the available repaired prototypes, the program will test each type of repair. Any development activities required to apply a given test protocol to this program will be completed in this phase.

The repaired W/WS will be subjected to the tests defined in the validated test plan. The prototypes will be selected randomly within the same type of W/WS to ensure unbiased testing. The test data developed with the new W/WS will form the performance baseline the repaired W/WS will be compared with in the final test report.

At the conclusion of this test program, the W/WS prototypes will be functionally destroyed. Therefore, photographic and video documentation of the test results will be made throughout the program.

Figures 1 and 2 detail the test plan. Figure 1 shows the overall test plan. Figure 2 details the specific test schedule sequence.

4.0 TEST PROTOCOLS

4.1 General Inspection

All W/WS used in this program, new, repaired, and unrepaired, will undergo a thorough general inspection. Included in the inspection will be a visual physical condition examination, an electrical performance evaluation, an optical performance check, and a dimensional check.

4.1.1 Physical Condition

The physical condition of the W/WS will be evaluated using a visual inspection. Items to be evaluated during the inspection include:

- evidence of delamination
- vinyl cracks
- presence of scratches
- seal condition
- bumper condition
- electrical connector condition.

The physical condition will be documented with inspector notes, sketches, and photographs.

4.1.2 Electrical Performance

The resistance and insulation integrity of all W/WS will be evaluated against applicable Air Force Tech Orders and Specifications. Bus-to-bus resistance and sensor resistance, as applicable, will be measured using standard VOM techniques and will be compared to original specifications. Electrical insulation integrity will be tested using 2500 V_{rms} at 60 Hz between the bus and the sensor, and the bus and metal insert.

W/WS that meet resistance and insulation integrity specifications will have their heaters tested. A standard B-52 power supply or equivalent with the appropriate transformer taps will be used to power up windows simulating normal operation. Infrared imaging by video, non-contact thermometry, and still photography will be used to document heater performance. Sensor operation will be evaluated based on its ability to properly regulate heater operation. Applicable Tech Orders and Specifications will be used to evaluate heater performance.

4.1.3 Optical Performance

The optical performance of the W/WS will be assessed by measuring haze and transmittance, optical distortion, and optical deviation. Haze and transmittance measurements will be made at the center of the W/WS in accordance with ASTM D 1003-92. Optical distortion will be assessed using a single exposure photograph of the W/WS against a grid board background. Optical deviation will be measured at 12 locations on each W/WS in accordance with MIL-G-25871B paragraph 4.4.6.2 or equivalent.

4.1.4 Dimensional Tolerances

Physical dimensions of the W/WS will be measured and compared to Air Force supplied allowable tolerances. The purpose of this inspection is to develop data to determine if changes to the W/WS caused by the repair processes impact the usability and fitness of the repaired W/WS for use by the Air Force. The critical dimensions therefore include proper mounting frame fit dimensions, location of electrical connections, thickness of the assembly, and thickness at the edges of the W/WS. To facilitate the thickness measurements, a template with 12 locations for measuring the assembly thickness will be supplied. Eight locations will be identified for edge thickness measurements. Standard physical measuring devices will be used to make the required measurements.

4.2 Pressure Integrity

4.2.1 General

The pressure integrity of the W/WS prototypes will be evaluated by applying sequential pressure tests. The following tests will be performed on prototypes of the #1, #2, and escape hatch W/WS. The first test is a non-disabled proof pressure test. A non-disabled test specimen is a W/WS which has not purposely been broken prior to the test. Samples which pass will undergo cyclic durability testing. Finally, samples which pass the cyclic durability test will again be exposed to a non-disabled proof pressure test. Details of the test protocols are described in the following sections. The incoming W/WS will be installed in the test fixture and will be

sequentially tested without removal or refixturing, if the mounting integrity shows no degradation between tests.

The number and type of W/WS to be pressure integrity tested are as follows:

Type of W/WS	Total W/WS	Unrepaired	Vendor #1	Vendor #2	New W/WS
#1	5	0	2	2	1
#2	5	0	2	2	1
Escape Hatch	5	0	2	2	1
	15 total for program				

4.2.2 Proof Pressure Test

This test will be conducted as an initial acceptance and final test. The test article will be mounted in a simulated aircraft frame and installed per applicable Air Force Tech Orders. The test fixture will then be pressurized at a rate not to exceed 1.0 psi/minute to 1.24 times the release valve setting of 15.0 psi, 18.6 psi. This final pressure will be maintained for 15 minutes and then slowly released. The test will be conducted at ambient temperature. At completion, the W/WS will be inspected for delamination and electrical resistance and the results recorded. This test will be performed initially on all pressure integrity test W/WS and on pressure integrity test W/WS that have passed the cyclic durability test.

4.2.3 Cyclic Durability

This test will be conducted on all W/WS which have passed the initial proof pressure test. The test will be conducted with an outward acting pressure and a specified thermal condition. The cyclic test will continue until the W/WS fails to maintain pressure or the specified number of pressure cycles is applied (runout). If a failure occurs, the number of cycles to failure will be recorded as well as the failure mode. In the case of an earlier nonstructural failure, the cycling will continue until the test article is incapable of maintaining pressure or runout occurs. The prototypes will be inspected for delamination at specified times during the testing.

During cyclic pressure testing, the following data will be recorded continuously:

- applied pressure
- outboard temperature
- inboard temperature
- bus-to-bus resistance
- power applied (watts) to the W/WS
- air velocity, as applicable.

As long as all other requirements are met, multiple specimens may be tested in a single set-up. The test facility will supply all hardware, mounting frames, etc. to conduct the tests. Mounting frames will be reverse engineered from new W/WS.

4.2.3.1 #1 and #2 W/WS

The #1 and #2 W/WS cyclic durability test will be conducted per the schedule shown in Table 1. A total of 500 pressure cycles will be applied, unless there is an earlier structural failure.

4.2.3.2 Escape Hatch W/WS

The escape hatch W/WS cyclic durability test will be conducted per the schedule shown in Table 2. A total of six pressure/thermal cycles will be applied in the first stage of testing, with two pressure holds at the end.

4.3 Bird Impact Testing

Bird impact testing will be performed on #1 and #2 W/WS prototypes in the spirit of ASTM F 330-89. The available prototypes will be selected in a manner which will allow testing of the greatest number of repair techniques. Delamination repairs must be tested for bird impact. The W/WS will be mounted in a simulated airframe support structure. A real 4- pound bird will impact the center of the W/WS at the correct angle for head-on level flight. W/WS will be installed in the testing frame IAW Air Force applicable Tech Orders and Specifications.

The target impact velocity is 400 knots. There is some concern, however, that neither the repaired or the new W/WS will be able to withstand an impact at this velocity. Therefore, to qualify the test impact velocity, up to five impact tests each on #1 and #2 unrepaired W/WS will be conducted to select a test velocity. The goal in selecting an impact velocity is to find the highest velocity that does not result in a catastrophic failure of the W/WS. Once qualified, the selected impact velocity will be used for the actual test articles.

The test facility will supply all the items and equipment necessary to run this test in the spirit of ASTM F 330-89. Mounting test frames suitable for the B-52 W/WS will be fabricated by the test facility through reverse engineering. Documentation of the facility's compliance with ASTM specifications will be provided by the test facility.

Documentation of the test results will include still photos and assignment of a pass/fail rating based on resistance to penetration. High-speed film documentation of the tests is required. A recording sensing paper will be installed behind the test specimen to document spalling caused by the impact.

The number and type of W/WS to be bird impact tested are listed in the following table:

Type of W/WS	Total W/WS	Unrepaired	Vendor #1	Vendor #2	New W/WS
#1	up to 10	up to 5	2	2	1
#2	up to 10	up to 5	2	2	1

5.0 QUALITY ASSURANCE

All of the testing must be performed in accordance with the specified standards, or using prudent laboratory practices. All instrumentation used in the tests will have a traceable calibration within the preceding 12 months and suitable calibration records will be maintained to verify that such calibrations are valid. From time to time, pre-arranged visits to the test site will be made to witness testing and inspect laboratory records.

6.0 FURNISHED EQUIPMENT/DATA

The following hardware will be provided for conducting the tests outlined above:

- New W/WS: 2 each #1, #2, and escape hatch
- Repaired W/WS, 8 each #1 and #2, and 4 escape hatch
- Unrepaired W/WS, 5 each #1 and #2
- Seals
- Samples of W/WS fasteners
- Escape hatch thermal sensors.

Information from applicable USAF technical orders, specifications, and drawings, will be furnished as required to conduct test plan.

7.0 REPORTING REQUIREMENTS

The reporting requirements are as follows:

1) Written test plan for review and approval, submitted prior to beginning testing.

2) Brief monthly status reports.

3) Final report.

The format of the required reporting documents is at the discretion of the test facility. The final report, however, should contain at a minimum the following:

1) A written description of the test procedures (from the approved test plan)

2) Photographs of the test set-ups

3) Initialed inspector's data sheets and notes from the general inspection
   - written visual condition comments
   - resistance measurements
   - insulation pass/fail rating
   - 35 mm color photo of the thermographic image
   - transmittance and haze measurements
   - optical distortion photograph
   - optical deviation measurements
   - W/WS thickness measurements
   - physical tolerance pass/fail rating

4) Pressure integrity testing results
   - pre-test photograph
   - post-test photograph with any delamination or other distress identified
   - written summary of test results

5) Bird impact testing results
   - pre-test photograph
   - post-test photograph
   - high-speed films of impacts
   - written summary of test parameters and description of W/WS damage

6) Serial numbers and calibration records for the instrumentation

TABLE 1. CYCLIC PRESSURE INTEGRITY TESTING SCHEDULE FOR B-52 #1 AND #2 W/WS

Step	Outboard Air Temp, F	Inboard Air Temp, F	Applied Pressure, psi	Applied Voltage, volts	Heat Input, watts	Time Conditions Maintained	Remarks
1	-65	70	-	-	-	until temps stabilized	-
2	-65	70	-	*	-	until temps stabilized	apply power
3	-65	70	-	*	*	until deflections and temps stabilized	adjust air velocity so that heat input is dissipated without voltage cycling or changing temperature control
4	-65	70	15	-	-	250 cycles	1 psi/min pressure and depressure rate
5	-65	70	-	-	-	until temps stabilized	remove power
6	70	70	-	-	-	until temps stabilized	return to ambient conditions
7	Inspect for delamination						
8-14	Repeat Steps 1-7						

*

W/WS	W/WS Letter Code	Voltage, volts	Power, watts
#1	H1	330	2380
	H2	314	
	H3	298	
#2	H1	441	2600
	H2	421	
	H3	398	

TABLE 2. CYCLIC PRESSURE INTEGRITY TESTING SCHEDULE FOR B-52 ESCAPE HATCH W/WS

Step	Outboard Air Temp, F	Inboard Air Temp, F	Applied Pressure, psi	Applied Voltage, volts	Heat Input, watts	Time Conditions Maintained	Remarks
1	-65	70	-	-	-	until temps stabilized	-
2	-65	70	-	161	-	until temps stabilized	apply power
3	-65	70	10	161	-	until deflections stabilized	apply pressure
4	-65	70	10	161	426	until deflections and temps stabilized	adjust air velocity so that heat input is dissipated without voltage cycling or changing temperature control
5	-65	70	-	-	-	until deflections stabilized	remove pressure and reduce air velocity to zero
6	-65	70	-	-	-	until temps stabilized	remove power
7	70	70	-	-	-	until temps stabilized	return to ambient conditions
8	Inspect for delamination						
9-48	Repeat Steps 1-8 five times, increasing the pressure applied at Steps 3 and 4 in 1 psi increments to a maximum of 15 psi						
49	-65	70	-	-	-	until temps stabilized	-
50	-65	70	-	161	-	until temps stabilized	apply power
51	-65	70	-	161	426	until temps stabilized	adjust air velocity so that heat input is dissipated without voltage cycling or changing temperature control
52	-65	70	13	161	426	30 minutes	apply pressure
53	-65	70	18.6	161	426	30 minutes	add pressure increment
54	70	70	-	-	-	until temps stabilized	return to ambient conditions
55	Inspect for delamination						

APPENDIX C

B-52 W/WS INSPECTION SHEETS

PPG Part Number: Bac - 061-4

Customer Part Number 10-30347-7

Unit Serial Number 2-H-1-28-92

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 46.3 Ω		Acc	MAY 04 1995	22 PPG 55
Thermal Image			5/9/1995	
S.E. Resistance 308		Acc	MAY 04 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 04 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 04 1995	22 PPG 55
Light Transmittance: 75.5		Acc	MAY 04 1995	22 PPG 55
Haze: 1.3		Acc	MAY 04 1995	22 PPG 55
Photo (Single Exposure):			MAY 08 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 2.0	2: 1.0	3: 3.0	4: 3.0	5: 2.0	6: 3.0
7: 1.0	8: 3.0	9: 3.0	10: 2.0	11: 2.0	12: 6.0

Dimensional Inspection: Acc MAY 04 [illegible] 22 PPG 55

Unit Thickness (per Template)

1: 1.022	2: 1.008	3: 1.014	4: 1.010	5: 1.011	6: 1.014
7: 1.010	8: 1.008	9: 1.006	10: 1.006	11: 1.004	12: 1.008

Edge Thickness (per Template)

1: .832	2: .830	3: .820	4: .835
5: .814	6: .806	7: .821	8: .819

Seal Evaluation: Acc MAY 04 [illegible] 22 PPG 55
(Comments) Good

Visual Inspection: Acc in Slip Plant Location MAY 04 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bac-061-4

CUSTOMER PART NUMBER 10-30347-7

UNIT SERIAL NUMBER 7-A-1-25-92

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- See Sketch

SEAL CONDITION- Good

ELECTRICAL CONNECTOR CONDITION- Good

PPG PART NUMBER Bac - c61 - 4

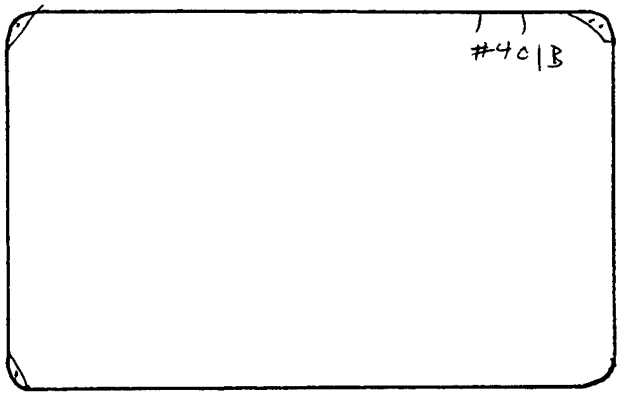
CUSTOMER PART NUMBER 10 - 30347-7

UNIT SERIAL NUMBER 7-N-1-28-92

VISUAL INSPECTION AND COMMENTS

Air in slip plane

Scratches #4 O/B



BAC - 061

PPG Part Number: Bac-061-4

Customer Part Number 10-30347-7

Unit Serial Number 83-4/-3-21-110

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 51.8 Ω		Rej.	MAY 04 1995	22 PPG 55
Thermal Image			5/9/1995	~~22 PPG 55~~
S.E. Resistance 308		acc	MAY 04 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	acc	MAY 04 1995	22 PPG 55
	S.E. to Metal	acc		
	S.E. to S.E.	NA		
NESA Scratch Test (350 VAC):		acc	MAY 04 1995	22 PPG 55
Light Transmittance: 74.5		acc	MAY 04 1995	22 PPG 55
Haze: 1.2		acc	MAY 04 1995	22 PPG 55
Photo (Single Exposure):			MAY 08 1995	22 PPG 23

OPERATOR NON-PPG 22-135 INSPECTION

Deviation Inspection
(Per Template)

1: 6.0	2: 2.0	3: 6.0	4: 2.0	5: 2.0	6: 2.0
7: 1.0	8: 2.0	9: 2.0	10: 3.0	11: 3.0	12: 4.0

Dimensional Inspection: acc MAY 04 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.017	2: 1.015	3: 1.015	4: 1.010	5: 1.009	6: 1.009
7: 1.011	8: 1.010	9: 1.009	10: 1.014	11: 1.015	12: 1.017

Edge Thickness (per Template)

1: .852	2: .833	3: .832	4: .848
5: .850	6: .845	7: .851	8: .864

Seal Evaluation: acc MAY 04 1995 22 PPG 55
(Comments) Good

Visual Inspection: Air in Seal Space MAY 04 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Baa-061-4

CUSTOMER PART NUMBER 10-303427

UNIT SERIAL NUMBER 83-A-3-21-110

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- None

SEAL CONDITION- Good

ELECTRICAL CONNECTOR CONDITION- Good

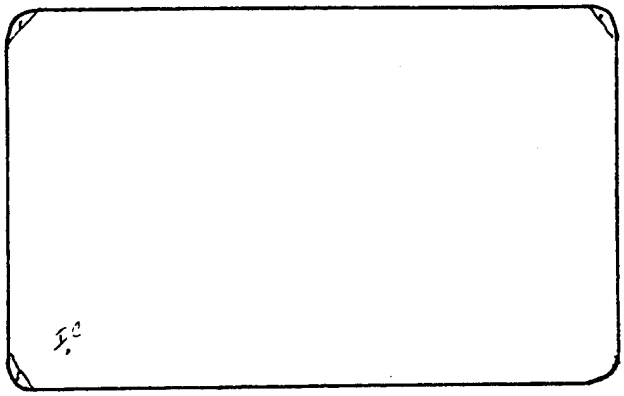
PPG PART NUMBER Bac-061-4

CUSTOMER PART NUMBER 16-30347-7

UNIT SERIAL NUMBER 82-A-321-110

VISUAL INSPECTION AND COMMENTS

Air in S/E & Stiff Plane



BAC-061

Used

PPG Part Number: Bae -0614

Customer Part Number 10-30347-7

Unit Serial Number 86-H-03-03-298

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 49.3 Ω		Acc	MAY 04 1995	22 PPG 55
Thermal Image			5/9/1995	
S.E. Resistance 308		Acc	MAY 04 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 04 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 04 1995	22 PPG 55
Light Transmittance: 79.1		Acc	MAY 04 1995	22 PPG 55
Haze: 1.1		Acc	MAY 04 1995	22 PPG 55
Photo (Single Exposure):			MAY 08 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 2.0	2: 3.0	3: 4.0	4: 2.0	5: 2.0	6: 2.0
7: 2.0	8: 2.0	9: 2.0	10: 2.0	11: 4.0	12: 4.0

Dimensional Inspection: Acc MAY 04 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.052	2: 1.054	3: 1.060	4: 1.050	5: 1.054	6: 1.053
7: 1.053	8: 1.053	9: 1.053	10: 1.056	11: 1.054	12: 1.056

Edge Thickness (per Template)

1: 854	2: .883	3: .878	4: .872
5: .868	6: .873	7: .862	8: .882

Seal Evaluation: MAY 04 1995 22 PPG 55
(Comments) Used

Visual Inspection: Acc MAY 04 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bac-061-4

CUSTOMER PART NUMBER 10-30347-7

UNIT SERIAL NUMBER 86-A-03-03-298

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- None

SEAL CONDITION- Good

ELECTRICAL CONNECTOR CONDITION- Good

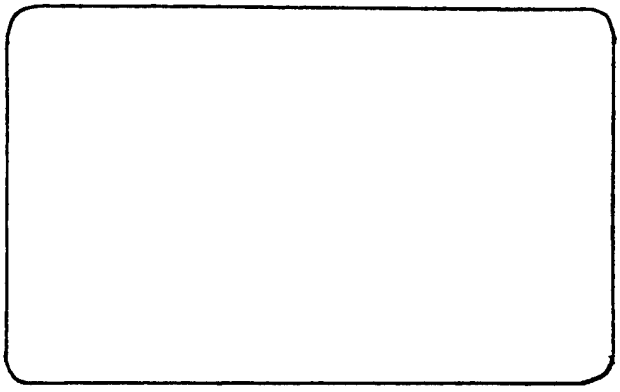
PPG PART NUMBER Bac-061-4

CUSTOMER PART NUMBER 10-30347-7

UNIT SERIAL NUMBER 86-H-03-03-298

VISUAL INSPECTION AND COMMENTS

No Scratches



BAC-061

Used

PPG Part Number: Bae -061-4

Customer Part Number 10-30347-7

Unit Serial Number 864-64-28-693

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 528 Ω		Acc	MAY 04 1995	22 PPG
Thermal Image			5/9/1995	
S.E. Resistance 309		Acc	MAY 04 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 04 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 04 1995	22 PPG 55
Light Transmittance:		Acc 79.6	MAY 04 1995	22 PPG 55
Haze:		Acc 1.1	MAY 04 1995	22 PPG 55
Photo (Single Exposure):			MAY 08 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 6.0	2: 2.0	3: 4.5	4: 2.0	5: 2.0	6: 2.0
7: 2.0	8: 2.0	9: 9.0	10: 2.0	11: 4.5	12: 3.0

Dimensional Inspection: Acc MAY 04 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.060	2: 1.047	3: 1.037	4: 1.047	5: 1.051	6: 1.047
7: 1.050	8: 1.047	9: 1.050	10: 1.056	11: 1.047	12: 1.052

Edge Thickness (per Template)

1: .843	2: .870	3: .860	4: .872
5: .888	6: .884	7: .848	8: .877

Seal Evaluation: Acc MAY 04 1995 22 PPG 55
(Comments) Used

Visual Inspection: See Sketch MAY 04 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bac - 061 - 4

CUSTOMER PART NUMBER 10 - 30347 - 7

UNIT SERIAL NUMBER 86 - A - 04 - 28 - 693

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- See Sketch

SEAL CONDITION- Good

ELECTRICAL CONNECTOR CONDITION- Good

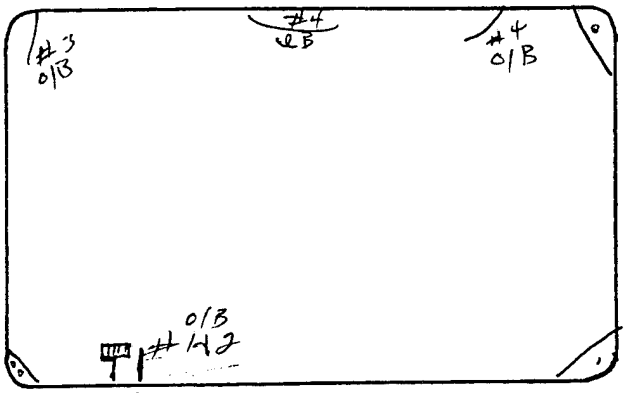
PPG PART NUMBER Bac - 061 - 4

CUSTOMER PART NUMBER 10 - 30347 - 7

UNIT SERIAL NUMBER 86 - A - 04 - 28 - 693

VISUAL INSPECTION AND COMMENTS

Scratches see Sketch



PPG Part Number: Bac-061-4

Customer Part Number 10-303477

Unit Serial Number 37-H-11-02-614

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 42.2 Ω		Acc	MAY 04 1995	22 PPG 55
Thermal Image			5/9/1995	OPERATOR COMMISSIONED PPG 22-13 INSPECTOR
S.E. Resistance 308		Acc	MAY 04 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 04 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 04 1995	22 PPG 55
Light Transmittance: 76.6		Acc	MAY 04 1995	22 PPG 55
Haze: 1.2		Acc	MAY 04 1995	22 PPG 55
Photo (Single Exposure):			MAY 08 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 2.0	2: 2.0	3: 3.0	4: 2.0	5: 3.0	6: 2.0
7: 2.0	8: 2.0	9: 2.0	10: 5.0	11: 4.0	12: .5

Dimensional Inspection: Acc MAY 04 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.038	2: 1.039	3: 1.042	4: 1.041	5: 1.043	6: 1.041
7: 1.042	8: 1.039	9: 1.042	10: 1.042	11: 1.037	12: 1.038

Edge Thickness (per Template)

1: .867	2: .877	3: .870	4: .860
5: .860	6: .867	7: .885	8: .895

Seal Evaluation: Acc MAY 04 1995 22 PPG 55
(Comments) Good

Visual Inspection: No scratches ≥ .005 MAY 04 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bac-061-4

CUSTOMER PART NUMBER 10-30347-7

UNIT SERIAL NUMBER 57-H-11-02-614

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- None

SEAL CONDITION- Good

ELECTRICAL CONNECTOR CONDITION- Good

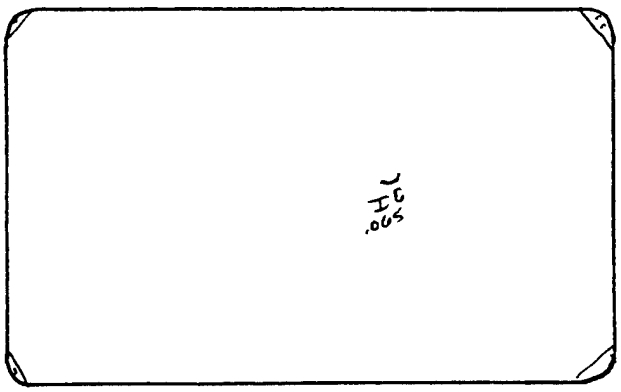
PPG PART NUMBER Bac-061-4

CUSTOMER PART NUMBER 10-30347-7

UNIT SERIAL NUMBER 87-84-11-02-614

VISUAL INSPECTION AND COMMENTS

No Scratches. IC .065



BAC-061

Uncoated

PPG Part Number: Bare - 061 - 4

Customer Part Number 10-30347-7

Unit Serial Number 89-116-10-366

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 43.4 Ω		Acc	MAY 04 1995	22 PPG 55
Thermal Image			5/9/1995	
S.E. Resistance 306		Acc	MAY 04 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 04 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 04 1995	22 PPG 55
Light Transmittance: 77.6		Acc	MAY 04 1995	22 PPG 55
Haze: 1.0		Acc	MAY 04 1995	22 PPG 55
Photo (Single Exposure):			MAY 08 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: .5	2: 4.0	3: 4.0	4: 4.0	5: 4.0	6: 4.0
7: 3.0	8: 3.0	9: 3.0	10: 3.0	11: 3.0	12: 4.0

Dimensional Inspection: Acc MAY 04 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.003	2: 1.023	3: 1.003	4: 1.032	5: 1.020	6: 1.021
7: 1.020	8: 1.020	9: 1.019	10: 1.025	11: 1.020	12: 1.020

Edge Thickness (per Template)

1: .853	2: .848	3: .835	4: .813
5: .845	6: .860	7: .870	8: .873

Seal Evaluation: Acc MAY 04 1995 22 PPG 55
(Comments) Good

Visual Inspection: Some Scratches no face #4 Acc MAY 04 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bac-061-4

CUSTOMER PART NUMBER 10-30347-7

UNIT SERIAL NUMBER 89-116-HO-366

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- See Sketch

SEAL CONDITION- Good

ELECTRICAL CONNECTOR CONDITION- Good

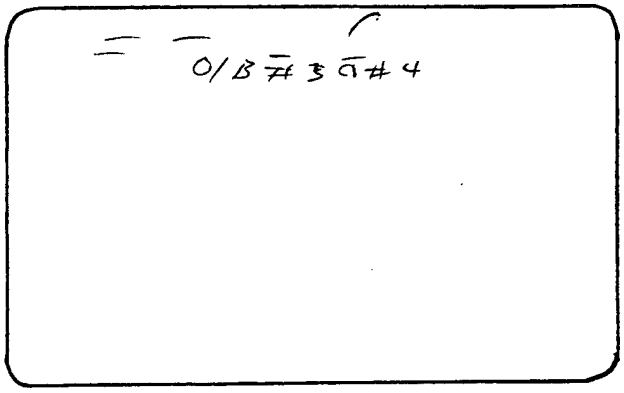
PPG PART NUMBER Bac-061-4

CUSTOMER PART NUMBER 16-303477

UNIT SERIAL NUMBER 89-116-HO-366

VISUAL INSPECTION AND COMMENTS

Several Scratch O/B more large than #4



BAC-061

PPG Part Number: Bec 061-4

Customer Part Number 10-30347-7

Unit Serial Number 89-216-NO.298

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 428 Ω		Acc	MAY 04 1995	22 PPG 55
Thermal Image			5/9/1995	
S.E. Resistance 308		Acc	MAY 04 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Short	MAY 04 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 04 1995	22 PPG 55
Light Transmittance: 77.5		Acc	MAY 04 1995	22 PPG 55
Haze: 1.0		Acc	MAY 04 1995	22 PPG 55
Photo (Single Exposure):			MAY 08 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 6.0	2: 4.5	3: 6.0	4: 3.0	5: 3.0	6: 3.0
7: 1.0	8: 1.0	9: 2.0	10: 4.5	11: 4.0	12: 4.5

Dimensional Inspection: Acc. MAY 04 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.022	2: 1.015	3: 1.024	4: 1.015	5: 1.018	6: 1.017
7: 1.021	8: 1.022	9: 1.018	10: 1.021	11: 1.017	12: 1022

Edge Thickness (per Template)

1: .843	2: .848	3: .858	4: .855
5: .803	6: .816	7: .856	8: .853

Seal Evaluation: Acc MAY 04 1995 22 PPG 55
(Comments) Good

Visual Inspection: Air in S/E light detectable Acc MAY 04 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bac-061-4

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 59-216-Ac-098

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- Light Scratches Top & Bottom 01B

SEAL CONDITION- Good

ELECTRICAL CONNECTOR CONDITION- Good

PPG PART NUMBER Bac-061-4

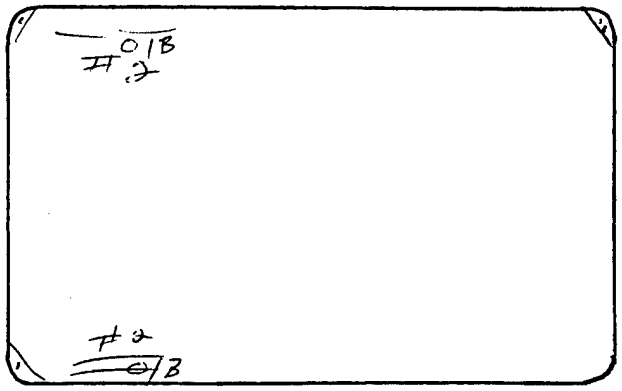
CUSTOMER PART NUMBER 10-303477

UNIT SERIAL NUMBER 89-216-HO-298

VISUAL INSPECTION AND COMMENTS

Air in S/E

Light Scratches



BAC-061

PPG Part Number: Bar-061-4

Customer Part Number 10-30347-7

Unit Serial Number S3H-3-21-109

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 459 Ω		Acc	MAY 04 1995	22 PPG 55
Thermal Image		Acc	5/9/1995	
S.E. Resistance 309		Acc	MAY 04 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 04 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 04 1995	22 PPG 55
Light Transmittance: 75.6		Acc	MAY 04 1995	22 PPG 55
Haze: .9		Acc	MAY 04 1995	22 PPG 55
Photo (Single Exposure):			MAY 08 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 3.0	2: 2.0	3: 2.0	4: 2.0	5: 2.0	6: 2.0
7: .05	8: 3.0	9: 1.0	10: 3.0	11: 2.0	12: 2.0

Dimensional Inspection: Acc MAY 04 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.008	2: 1.007	3: 1.007	4: 1.007	5: 1.004	6: 1.006
7: 1.004	8: 1.006	9: 1.005	10: 1.004	11: 1.004	12: 1.004

Edge Thickness (per Template)

1: .827	2: .830	3: 846	4: 835
5: 837	6: 844	7: 849	8: 839

Seal Evaluation: Acc MAY 04 1995 22 PPG 55
(Comments) Good

Visual Inspection: Air in S/E at Slip Plane MAY 04 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bnc-061-4

CUSTOMER PART NUMBER 10-30347-7

UNIT SERIAL NUMBER 83-H-3-21-109

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- See Sketch

SEAL CONDITION- Good

ELECTRICAL CONNECTOR CONDITION- Good

PPG PART NUMBER Bac - C61 - 4

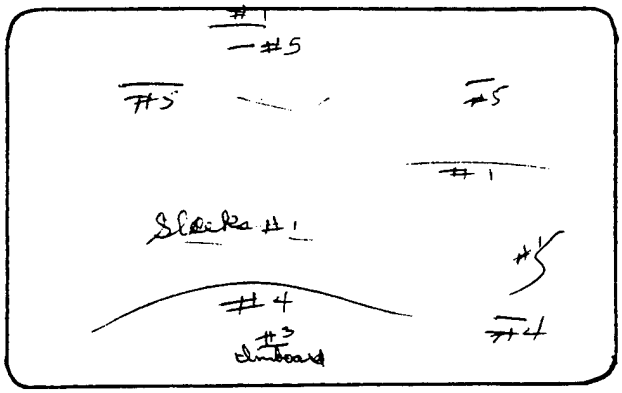
CUSTOMER PART NUMBER 16 - 30347 - 7

UNIT SERIAL NUMBER 83 - [illegible] - 3 - 21 - 109

VISUAL INSPECTION AND COMMENTS

Air in S/E & Slip plane

Scratches on O/B one on I/B



BAC - 061

PPG Part Number: Bac-061-4

Customer Part Number 10-30347-7

Unit Serial Number 87-A-11-02-396

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 43.4 Ω		Acc	MAY 03 1995	22 PPG 55
Thermal Image			5/9/1995	
S.E. Resistance 308		Acc	MAY 03 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 03 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 03 1995	22 PPG 55
Light Transmittance: 75.5		Acc	MAY 03 1995	22 PPG 55
Haze: .9		Acc	MAY 03 1995	22 PPG 55
Photo (Single Exposure):			MAY 08 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 2.0	2: 1.0	3: 4.5	4: 2.0	5: 2.0	6: 2.0
7: 2.0	8: 2.0	9: 2.0	10: 4.5	11: 2.0	12: 4.0

Dimensional Inspection: Acc MAY 03 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.020	2: 1.022	3: 1.026	4: 1.026	5: 1.023	6: 1.028
7: 1.028	8: 1.024	9: 1.026	10: 1.028	11: 1.025	12: 1.028

Edge Thickness (per Template)

1: .857	2: .830	3: .823	4: .825
5: .533	6: .816	7: .832	8: .839

Seal Evaluation: Acc MAY 03 1995 22 PPG 55
(Comments) _____

Visual Inspection: air in S/E _____ MAY 03 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bar-061-4

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 87-N-11-02-396

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- None

SEAL CONDITION- Good

ELECTRICAL CONNECTOR CONDITION- Good

PPG PART NUMBER Ban-C61-4

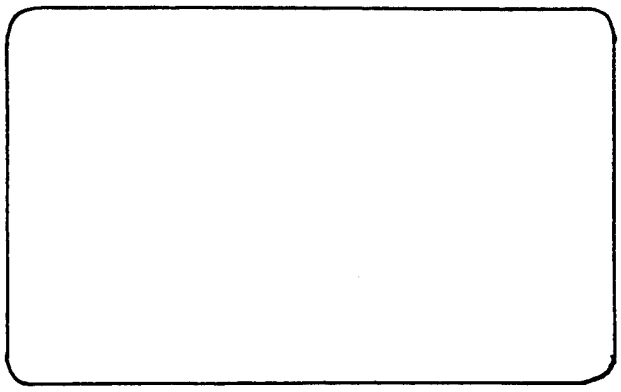
CUSTOMER PART NUMBER 10-30347-7

UNIT SERIAL NUMBER 87-H-11-02-396

VISUAL INSPECTION AND COMMENTS

Air in S/E

No Scratches



BAC-061

PPG Part Number: Bac -061-4

Customer Part Number 10-303477

Unit Serial Number 89-137-A0-152

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 400 Ω		Acc	MAY 03 1995 5/9/1995	22
Thermal Image			MAY 03 1995	
S.E. Resistance 306		Acc		22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 03 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 03 1995	22 PPG 55
Light Transmittance: 76.6		Acc	MAY 03 1995	22 PPG 55
Haze: 1.4		Acc	MAY 03 1995	22 PPG 55
Photo (Single Exposure):			MAY 08 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 4.5	2: 4.5	3: 4.5	4: 2.0	5: 2.0	6: 2.0
7: 2.0	8: 3.0	9: 2.0	10: 2.0	11: 5.0	12: 5.0

Dimensional Inspection: Acc MAY 03 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.015	2: 1.006	3: 1.009	4: 1.004	5: 1.003	6: 1.006
7: 1.011	8: 1.004	9: 1.002	10: 1.012	11: 1.008	12: 1.007

Edge Thickness (per Template)

1: .843	2: .836	3: .841	4: .856
5: .837	6: .842	7: .844	8: .842

Seal Evaluation: Acc MAY 03 1995 22 PPG 55
(Comments) _____

Visual Inspection: Acc MAY 03 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bac-061-4

CUSTOMER PART NUMBER 10-30347-7

UNIT SERIAL NUMBER 89-137-NO-152

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- None

SEAL CONDITION- Good

ELECTRICAL CONNECTOR CONDITION- Good

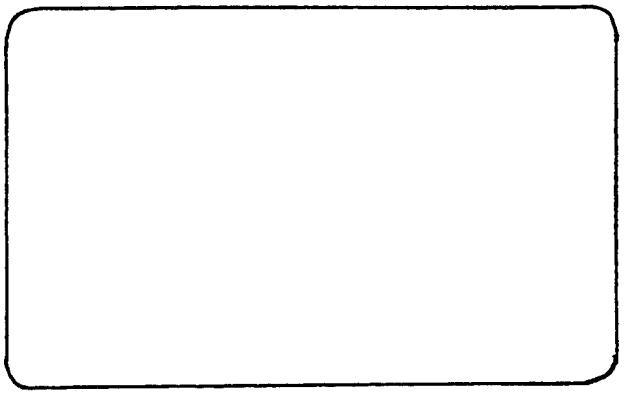
PPG PART NUMBER Bac - 061-4

CUSTOMER PART NUMBER 10-30347-7

UNIT SERIAL NUMBER 89-137-NO-152

VISUAL INSPECTION AND COMMENTS

No Scratches



BAC-061

PPG Part Number: Bar-061-4

Customer Part Number 10-30347-7

Unit Serial Number 92288NC631

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 44.4 Ω		Acc	MAY 04 1995	22 PPG 55
Thermal Image			5/9/1995	22 PPG 55
S.E. Resistance 308		Acc	MAY 04 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 04 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 04 1995	22 PPG 55
Light Transmittance: 79.0		Acc	MAY 04 1995	22 PPG 55
Haze: 1.0		Acc	MAY 04 1995	22 PPG 55
Photo (Single Exposure):			MAY 08 1995	22 PPG 23

Deviation Inspection (Per Template)

1: 4.5	2: 3.0	3: 5.0	4: 2.0	5: 2.0	6: 2.0
7: 2.0	8: 1.0	9: 2.0	10: 4.5	11: 2.0	12: 2.0

Dimensional Inspection: Acc MAY 04 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.026	2: 1.020	3: 1.029	4: 1.023	5: 1.023	6: 1.023
7: 1.022	8: 1.022	9: 1.023	10: 1.023	11: 1.022	12: 1.023

Edge Thickness (per Template)

1: .876	2: .852	3: .878	4: .891
5: .863	6: .864	7: .872	8: .883

Seal Evaluation: Acc MAY 04 1995 22 PPG 55
(Comments) Good

Visual Inspection: Excessive de cuttes MAY 04 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bac - C61 - 4

CUSTOMER PART NUMBER 10 - 3C347-7

UNIT SERIAL NUMBER 92288 H/C631

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- "Excessive" C1B Scratches None Greater than #4

SEAL CONDITION- Good

ELECTRICAL CONNECTOR CONDITION- Good

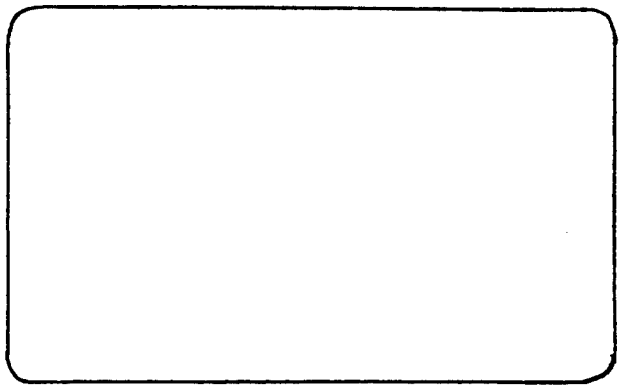
PPG PART NUMBER Bac-061-4

CUSTOMER PART NUMBER 10-30347-7

UNIT SERIAL NUMBER 92288HC631

VISUAL INSPECTION AND COMMENTS

Excessive 0/B Scratches None greater than #4



BAC-061

Used

PPG Part Number: Bac - 061 -4

Customer Part Number 10-30347-7

Unit Serial Number 9-H-11-19-503

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 50.2 Ω		Rej	MAY 0 3 1995	22 PPG 55
Thermal Image			5/9/1995	
S.E. Resistance 30 9		Acc	MAY 0 3 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 0 3 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A Acc		
NESA Scratch Test (350 VAC): Heavy Scratch		Rej.	MAY 0 3 1995	22 PPG 55
Light Transmittance:		76.2 Acc	MAY 0 3 1995	22 PPG 55
Haze:		1.0 Acc	MAY 0 3 1995	22 PPG 55
Photo (Single Exposure):			MAY 08 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 7.0	2: 9.0	3: 9.0	4: 3.0	5: 4.0	6: 4.0
7: 7.0	8: 3.0	9: 3.0	10: 7.0	11: 7.0	12: 6.0

Dimensional Inspection: Will not check In fixture — MAY 0 3 1995 — 22 PPG 55

Unit Thickness (per Template)

1: 1.040	2: 1.028	3: 1.030	4: 1.032	5: 1.027	6: 1.030
7: 1.031	8: 1.031	9: 1.028	10: 1.034	11: 1.027	12: 1.031

Edge Thickness (per Template)

1: .802	2: .790	3: .794	4: .795
5: .797	6: .790	7: .804	8: .803

Seal Evaluation: — MAY 0 3 1995 — 22 PPG 55
(Comments) Poor seal Cond.

Visual Inspection: — MAY 0 3 1995 — 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bac-061-4

CUSTOMER PART NUMBER 10-30347-7

UNIT SERIAL NUMBER 9-N-11-19-503

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- See Sketch

SEAL CONDITION- Poor

ELECTRICAL CONNECTOR CONDITION- OK

PPG PART NUMBER Bac-061-4

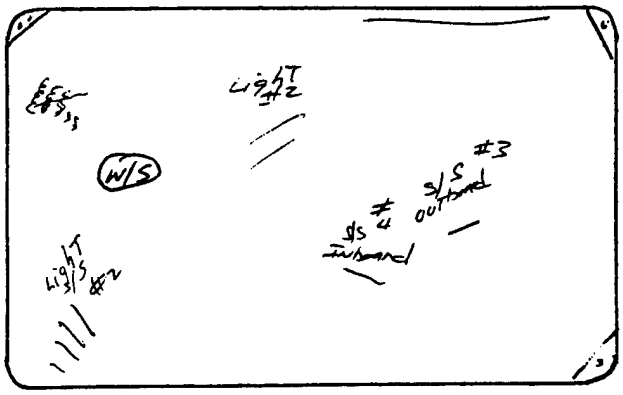
CUSTOMER PART NUMBER 10-30347-7

UNIT SERIAL NUMBER 9-H-11-19-503

VISUAL INSPECTION AND COMMENTS

Air in Sen/Element

Excessive Scratches None largerthan #4



BAC-061

PPG Part Number: Bac-061-4

Customer Part Number 10-30347-7

Unit Serial Number 86-H-03-17-221

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 52.4 Ω		Rej.	MAY 0 3 1995	22 PPG [illegible]
Thermal Image			5/9/1995	
S.E. Resistance 307		acc.	MAY 0 3 1995	22 PPG [illegible]
Insulation Test (2500 VAC)	Power to S.E.	acc	MAY 0 3 1995	22 PPG 55
	S.E. to Metal	acc		
	S.E. to S.E.	n/a		
NESA Scratch Test (350 VAC): None detected		Rej.	MAY [illegible]	22 PPG 55
Light Transmittance: 77.8		acc	MAY [illegible]	22 PPG 55
Haze: 1.1		acc.	MAY [illegible]	22 PPG 55
Photo (Single Exposure):			MAY 08 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 4.5	2: 2.0	3: 5.0	4: 8.0	5: 8.0	6: 8.0
7: 8.0	8: 7.0	9: 9.0	10: 9.0	11: 9.0	12: 9.0

Dimensional Inspection: will not check on fixture _____ MAY 0 3 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.056	2: 1.052	3: 1.060	4: 1.055	5: 1.057	6: 1.053
7: 1.055	8: 1.054	9: 1.060	10: 1.057	11: 1.061	12: 1.059

Edge Thickness (per Template)

1: .857	2: .852	3: .854	4: 860
5: 845	6: 842	7: 860	8: 846

Seal Evaluation: _____ MAY 0 3 1995 22 PPG 55
(Comments) Poor Seal Cont.

Visual Inspection: _____ MAY [illegible] 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bac-061-41

CUSTOMER PART NUMBER 16-30347-7

UNIT SERIAL NUMBER 86-A-03-17-221

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- 1 #7 Scratch & See Sketch

SEAL CONDITION- Poor

ELECTRICAL CONNECTOR CONDITION- OK

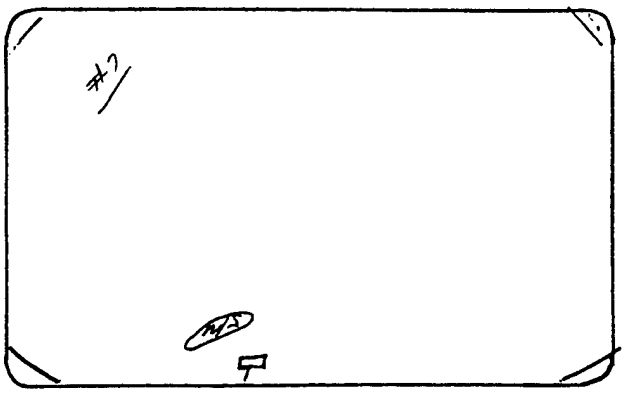
PPG PART NUMBER Bac-C61-4

CUSTOMER PART NUMBER 10-30347-7

UNIT SERIAL NUMBER 86-H-03-17-221

VISUAL INSPECTION AND COMMENTS

light scratches Inboard #7 Sec. stetal



BAC-061

used

PPG Part Number: Bar-061-4

Customer Part Number 10-30347-7

Unit Serial Number 87-H-11-30-749

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 43.1Ω		Acc.	MAY 0 3 1995	22 PPG 55
Thermal Image			5/9/1995	~~22 PPG 55~~ 5/3/95
S.E. Resistance 302		Acc.	MAY 0 3 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	OK	MAY 0 3 1995	22 PPG 55
	S.E. to Metal	Shorted		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 0 3 1995	22 PPG 55
Light Transmittance: 75.5		Acc	MAY 0 3 1995	22 PPG 55
Haze: 1.0		Acc	MAY 0 3 1995	22 PPG 55
Photo (Single Exposure):				

Deviation Inspection
(Per Template)

1: 5.0	2: 9.0	3: 4.0	4: 9.0	5: 4.0	6: 3.0
7: 3.0	8: 3.0	9: .5	10: 4.5	11: 2.0	12: 5.0

Dimensional Inspection: will not index in fixture — MAY 0 3 1995 — 22 PPG 55

Unit Thickness (per Template)

1: 1.050	2: 1.031	3: 1.038	4: 1.037	5: 1.038	6: 1.029
7: 1.037	8: 1.033	9: 1.030	10: 1.040	11: 1.035	12: 1.030

Edge Thickness (per Template)

1: .827	2: .824	3: .832	4: .821
5: .825	6: .838	7: .811	8: .808

Seal Evaluation: — MAY 0 3 1995 — 22 PPG 55
(Comments) Voids

Visual Inspection: Acc. — MAY 0 3 1995 — 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bac - C61-4

CUSTOMER PART NUMBER 10-30347-7

UNIT SERIAL NUMBER 97-H-11-30-749

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- N/A

SEAL CONDITION- Voids

ELECTRICAL CONNECTOR CONDITION- OK

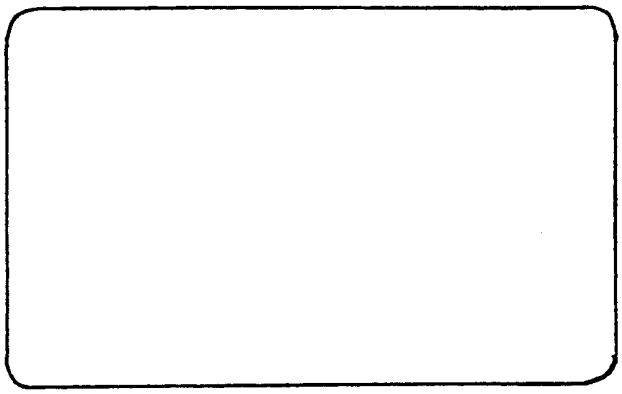
PPG PART NUMBER Bac -061-4

CUSTOMER PART NUMBER 16-30347-7

UNIT SERIAL NUMBER 87-A-11-30-749

VISUAL INSPECTION AND COMMENTS

OK



BAC-061

New

PPG Part Number: Bac-061-4

Customer Part Number 10-30347-7

Unit Serial Number 94-034A0742

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 426 Ω		Acc	MAY 04 1995	22 PPG 55
Thermal Image			5/9/1995	
S.E. Resistance 308		Acc	MAY 04 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 04 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 04 1995	22 PPG 55
Light Transmittance: 79.4		acc	MAY 04 1995	22 PPG 55
Haze: 1.2		acc	MAY 04 1995	22 PPG 55
Photo (Single Exposure):			MAY 08 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 3.0	2: 2.0	3: 2.0	4: 2.0	5: 3.0	6: 3.0
7: 2.0	8: 2.0	9: 2.0	10: 2.0	11: 2.0	12: 3.0

Dimensional Inspection: acc MAY 04 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.018	2: 1.012	3: 1.014	4: 1.008	5: 1.012	6: 1.009
7: 1.009	8: 1.009	9: 1.009	10: 1.014	11: 1.012	12: 1.014

Edge Thickness (per Template)

1: .882	2: .890	3: .888	4: .890
5: .884	6: .879	7: .885	8: .871

Seal Evaluation: acc MAY 04 1995 22 PPG 55
(Comments) Good

Visual Inspection: acc MAY 04 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bac - 061-4

CUSTOMER PART NUMBER 10-30347-7

UNIT SERIAL NUMBER 94034H0742

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- None

SEAL CONDITION- Good

ELECTRICAL CONNECTOR CONDITION- Good

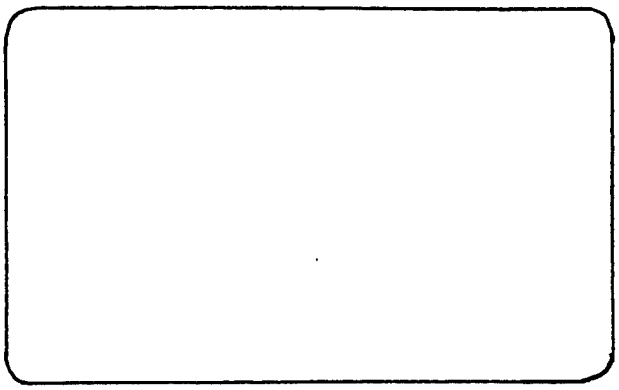
PPG PART NUMBER Bac - 061-4

CUSTOMER PART NUMBER 10-3C347-7

UNIT SERIAL NUMBER 94034A0742

VISUAL INSPECTION AND COMMENTS

No Scratches



BAC-061

PPG Part Number: Bac-C61-4

Customer Part Number 10-30347-7

Unit Serial Number 94-050HE241

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 40.8 Ω		Acc	MAY 03 1995	22 PPG 55
Thermal Image			5/9/1995	
S.E. Resistance 306		Acc	MAY 03 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	acc	MAY 03 1995	22 PPG 55
	S.E. to Metal	acc		
	S.E. to S.E. N/A	Acc		
NESA Scratch Test (350 VAC):		acc	MAY 03 1995	22 PPG 55
Light Transmittance: 77.6		acc	MAY 03 1995	22 PPG 55
Haze: 1.1		acc	MAY 03 1995	22 PPG 55
Photo (Single Exposure):			MAY 08 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 4.0	2: 4.0	3: 4.0	4: 4.0	5: 4.0	6: 4.0
7: 4.0	8: 4.0	9: 4.0	10: 3.0	11: 4.3	12: 4.3

Dimensional Inspection: acc MAY 03 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.035	2: 1.026	3: 1.028	4: 1.023	5: 1.026	6: 1.027
7: 1.030	8: 1.029	9: 1.026	10: 1.030	11: 1.025	12: 1.027

Edge Thickness (per Template)

1: .863	2: .865	3: .870	4: .853
5: 846	6: 877	7: 870	8: 866

Seal Evaluation: acc MAY 03 1995 22 PPG 55
(Comments)

Visual Inspection: acc MAY 03 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bac-061-4

CUSTOMER PART NUMBER 10-30347-7

UNIT SERIAL NUMBER 94050H0241

VISUAL INSPECTION

DELAMINATION- Good

VINYL CRACKS- Good

SCRATCHES- None

SEAL CONDITION- Good

ELECTRICAL CONNECTOR CONDITION- Good

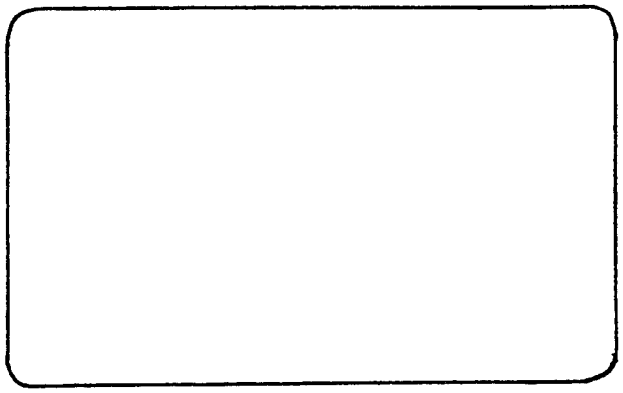
PPG PART NUMBER Bac-061-4

CUSTOMER PART NUMBER 10-30347-7

UNIT SERIAL NUMBER 94050NC241

VISUAL INSPECTION AND COMMENTS

No Scratches



BAC-061

PPG Part Number: BAC-065

Customer Part Number 10-30347-1

Unit Serial Number 5-H-3-20-17

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 71.5 Ω		Acc	MAY 09 1995	22 PPG 60
Thermal Image			5/11/95	
S.E. Resistance	309	Acc	MAY 08 1995	
Insulation Test (2500 VAC)	Power to S.E.	Acc	08 1995	22 PPG
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc		
Light Transmittance:	75.0	Acc		
Haze:	1.0	Acc		
Photo (Single Exposure):			MAY 09 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: .2	2: .2	3: .1	4: .3	5: .2	6: .2
7: .1	8: .1	9: .2	10: .2	11: .2	12: .3

Dimensional Inspection: Acc 22 PPG 60

Unit Thickness (per Template)

1: 1.26	2: 1.28	3: 1.28	4: 1.30	5: 126	6: 125
7: 130	8: 1.28	9: 1.26	10: 125	11: 1.25	12: 1.30

Edge Thickness (per Template)

1: 850	2: 864	3: 870	4: 863
5: 870	6: 864	7: 862	8: 858

Seal Evaluation: OK Acc

(Comments) See Chart

Visual Inspection: See chart Acc

(Place comments on attached sheet)

PPG PART NUMBER BAC-065

CUSTOMER PART NUMBER 10-30347-01

UNIT SERIAL NUMBER 5-H-3-20-17

VISUAL INSPECTION

DELAMINATION- Air in Slip Plane

VINYL CRACKS- OK

SCRATCHES- SEE CHART

SEAL CONDITION- OK

ELECTRICAL CONNECTOR CONDITION- OK

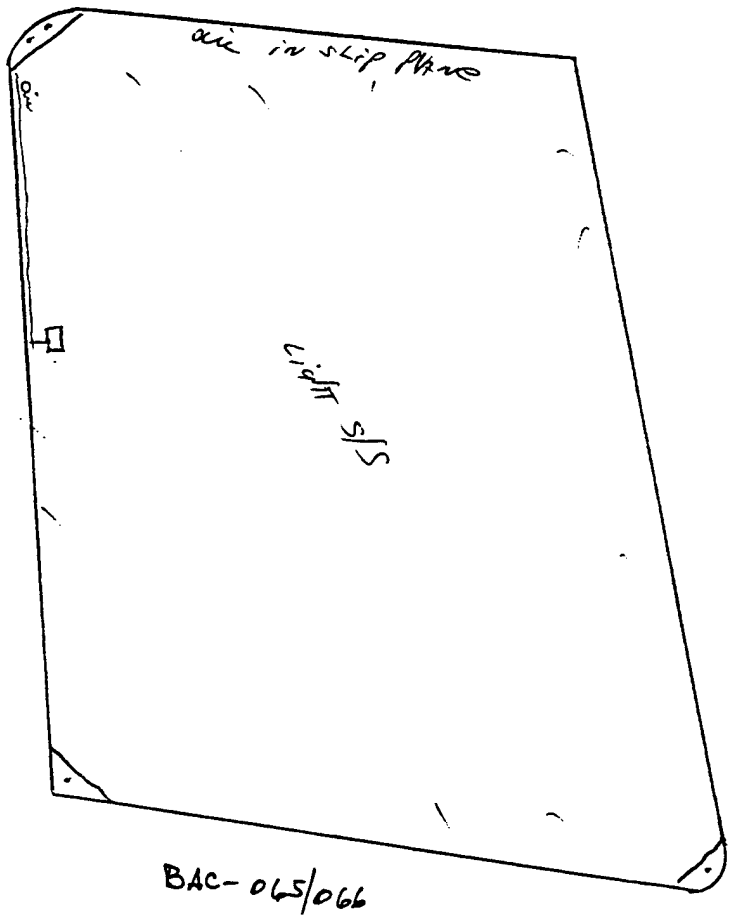
PPG PART NUMBER BAC-065

CUSTOMER PART NUMBER 10-30347-01

UNIT SERIAL NUMBER ~~5-3~~ S-H-3-20-17

VISUAL INSPECTION AND COMMENTS

Air in S/P & Light S/S Around Edge.



BAC-065/066

old

PPG Part Number: BAC-065

Customer Part Number 10-30347-1

Unit Serial Number 1-H-11-03-53

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	13.6Ω	Acc	MAY 08 1995	22 PP
Thermal Image			5/11/95	
S.E. Resistance	308	Acc	MAY 08 1995	22 PPG
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 08 1995	22 PPG 60
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 08 1995	22 PPG
Light Transmittance:	75.0	Acc	MAY 08 1995	22 PPG 60
Haze:	.9	Acc	MAY 08 1995	22 PPG 60
Photo (Single Exposure):			MAY 09 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 4.0	2: 4.0	3: 4.0	4: 2.0	5: 2.0	6: 1.0
7: 2.0	8: 2.0	9: 2.0	10: 2.0	11: 2.0	12: 2.0

Dimensional Inspection: Acc MAY 08 1995 PPG 60

Unit Thickness (per Template)

1: 1.57	2: 1.55	3: 1.57	4: 1.53	5: 1.58	6: 1.54
7: 1.57	8: 1.55	9: 1.50	10: 1.55	11: 1.58	12: 1.56

Edge Thickness (per Template)

1: 835	2: 844	3: 852	4: 850
5: 844	6: 852	7: 850	8: 846

Seal Evaluation: Acc MAY 08 1995 PPG 60
(Comments) SEE CHART

Visual Inspection: "SEE CHART" Acc PPG
(Place comments on attached sheet)

PPG PART NUMBER BAC-065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 7-H-11-03-53

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- See Chart

SEAL CONDITION- OK

ELECTRICAL CONNECTOR CONDITION- OK

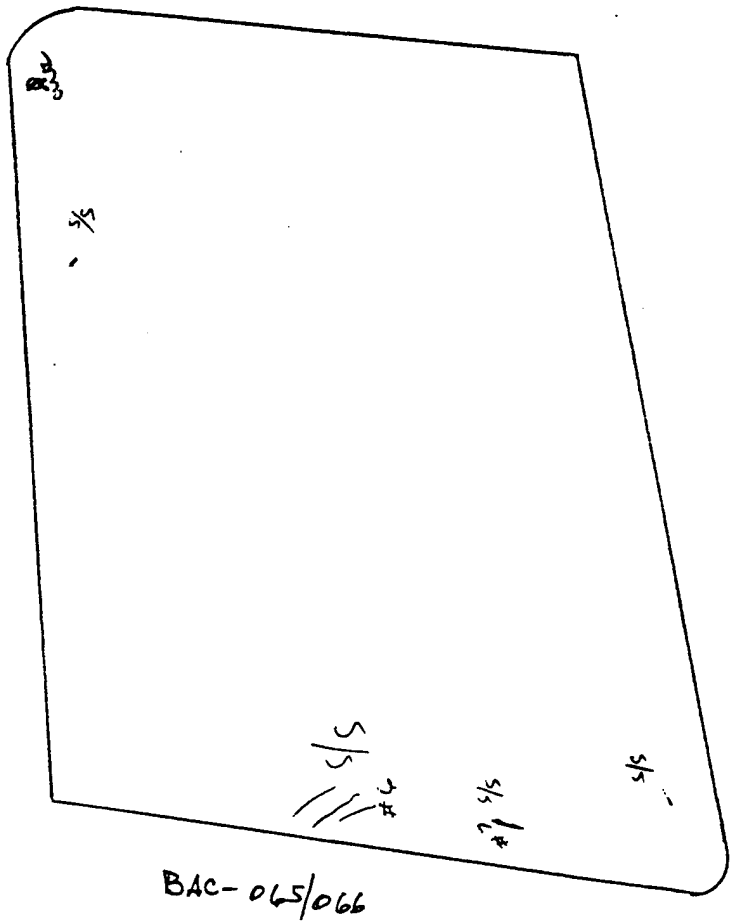
PPG PART NUMBER BAC-065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 7-H-11-03-53

VISUAL INSPECTION AND COMMENTS

S/S ; Air in Slip Plane



BAC-065/066

#240

PPG Part Number: BAC-065

Customer Part Number 10-30347-1

Unit Serial Number 8-H-11-20-277

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 79.0 Ω		Acc	[illegible]95	22 PPG [illegible]
Thermal Image			5/10/95	
S.E. Resistance	306	Acc	MAY 08 1995	22 PPG [illegible]
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 08 1995	22 PPG [illegible]
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):				
Light Transmittance:		74.5	MAY 08 1995	PPG [illegible]
Haze:		.9	MAY 08 1995	PPG [illegible]
Photo (Single Exposure):			MAY 09 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 1.0	2: 1.0	3: 1.0	4: .1	5: 1.0	6: 2.0
7: 1.0	8: 1.0	9: 1.0	10: 4.5	11: 2.0	12: 2.0

Dimensional Inspection: Acc MAY 08 1995 [illegible]

Unit Thickness (per Template)

1: 1.30	2: 1.42	3: 1.38	4: 1.35	5: 1.35	6: 1.35
7: 1.38	8: 1.35	9: 1.37	10: 1.38	11: 1.38	12: 1.39

Edge Thickness (per Template)

1: 848	2: 844	3: 854	4: 862
5: 850	6: 844	7: 850	8: 848

Seal Evaluation: Acc MAY 08 1995 [illegible]
(Comments) OK

Visual Inspection: OK MAY 08 1995 [illegible]
(Place comments on attached sheet)

PPG PART NUMBER BAC-065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 8-H-11-20-277

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- See Chart

SEAL CONDITION- OK

ELECTRICAL CONNECTOR CONDITION- OK

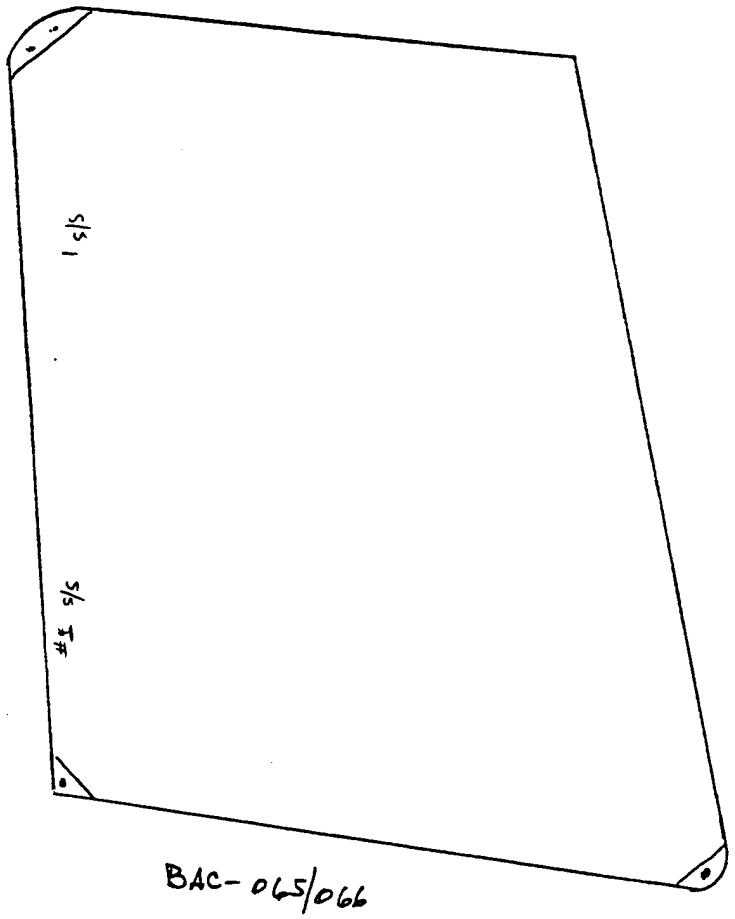
PPG PART NUMBER BAC-065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 8-H-11-20-277

VISUAL INSPECTION AND COMMENTS

Air in Slip Plane & Light S/S



BAC-065/066

PPG Part Number: Bae C65

Customer Part Number 16-30347-1

Unit Serial Number 8-H-11-20-434

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 766 Ω		Acc.	MAY 11 1995	22 PPG 55
Thermal Image			5/15/95	
S.E. Resistance 304		Acc	MAY 11 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 11 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc.	MAY 11 1995	22 PPG 55
Light Transmittance: 74.4		Acc	MAY 11 1995	22 PPG 55
Haze: .9		Acc	MAY 11 1995	22 PPG 55
Photo (Single Exposure):			MAY 12 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 3.0	2: 2.0	3: 3.0	4: 2.0	5: 2.0	6: 1.0
7: 1.0	8: 1.0	9: 1.0	10: 2.0	11: 2.0	12: 4.0

Dimensional Inspection: Acc. MAY 11 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.040	2: 1.037	3: 1.042	4: 1.034	5: 1.038	6: 1.041
7: 1.040	8: 1.035	9: 1.041	10: 1.041	11: 1.038	12: 1.040

Edge Thickness (per Template)

1: .830	2: .840	3: .890	4: .870
5: .845	6: .855	7: .862	8: .872

Seal Evaluation: Acc MAY 11 1995 22 PPG 55
(Comments) _____

Visual Inspection: Acc MAY 11 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bac 065

CUSTOMER PART NUMBER 16-30347-1

UNIT SERIAL NUMBER 8-14-11-20-434

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- See Sketch

SEAL CONDITION- Good

ELECTRICAL CONNECTOR CONDITION- Good

PPG PART NUMBER Bac065

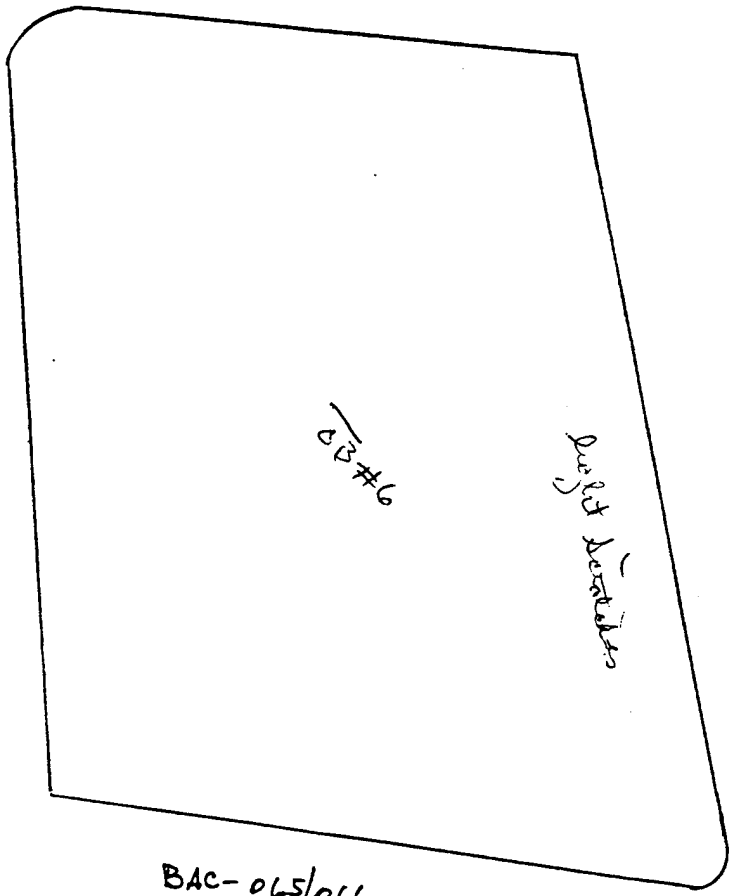
CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER S-N-11-20-434

VISUAL INSPECTION AND COMMENTS

Air in Slip Plane

Light Scratches at Top of Unit 1 small #6 O/B Middle of Unit



BAC-065/066

OLD

PPG Part Number: BAC-065

Customer Part Number IC-30347-1

Unit Serial Number XS-H-07-05-044

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 74.3 Ω		Acc	MAY 08 1995	PPG 80
Thermal Image		Acc	MAY 11 1995	22 PPG 23
S.E. Resistance	309	Acc	MAY 08 1995	PPG 80
Insulation Test (2500 VAC)	Power to S.E.	Acc	1995	PPG 80
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 08 1995	
Light Transmittance:		74.9	MAY 08 1995	
Haze:		1.1	1995	
Photo (Single Exposure):			1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 4.5	2: .2	3: .1	4: .1	5: .2	6: .2
7: 4.0	8: .2	9: .2	10: .2	11: .2	12: .3

Dimensional Inspection: Acc MAY 08 1995 PPG 80

Unit Thickness (per Template)

1: 1.50	2: 1.45	3: 1.52	4: 1.48	5: 1.50	6: 1.52
7: 1.50	8: 1.54	9: 1.56	10: 1.50	11: 1.50	12: 1.56

Edge Thickness (per Template)

1: 848	2: 852	3: 852	4: 860
5: 854	6: 870	7: 8606	8: 864

Seal Evaluation: OK Acc MAY 08 1995 PPG 80
(Comments) SEE CHART

Visual Inspection: SEE CHART Acc MAY 08 1995
(Place comments on attached sheet)

PPG PART NUMBER BAC-065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 85-H-07-05-044

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- SEE Chart

SEAL CONDITION- OK

ELECTRICAL CONNECTOR CONDITION- OK

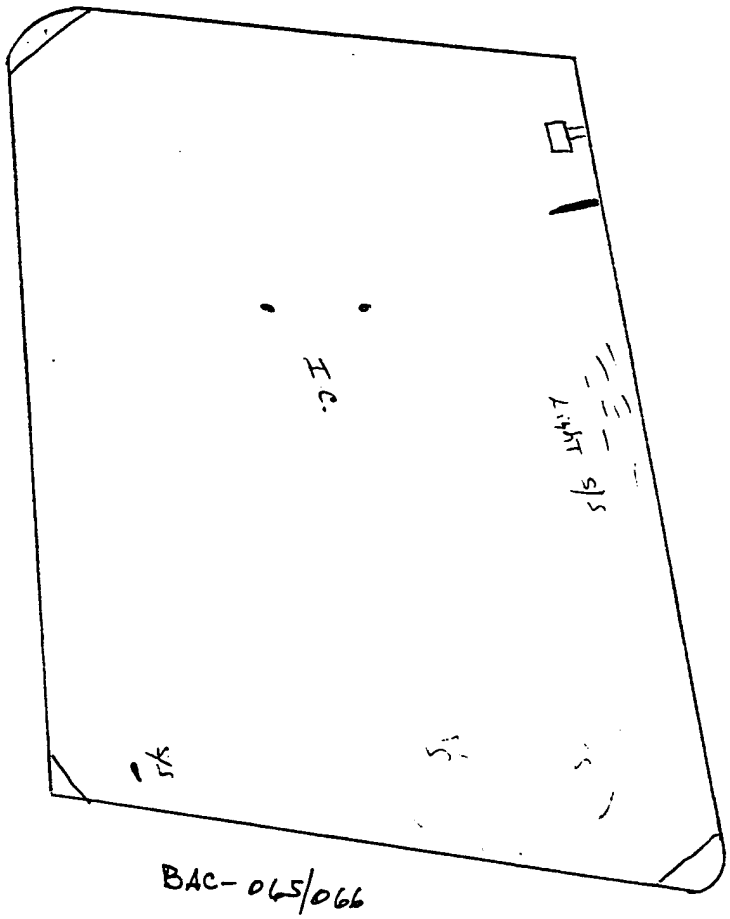
PPG PART NUMBER BAC-065

CUSTOMER PART NUMBER 1030347-1

UNIT SERIAL NUMBER 85-H-07-15-044

VISUAL INSPECTION AND COMMENTS

Light S/S, I.C.



BAC-065/066

DLC

PPG Part Number: BAC-065

Customer Part Number 10-30347-1

Unit Serial Number 86-H-07-14-260

		Acc/Rej	Date	Inspector
Bus to Bus Resistance:	738 Ω	Acc	MAY 08 1995	[illegible] PPG 60
Thermal Image			5/11/95	
S.E. Resistance	307	Acc	MAY 08 1995	[illegible] PPG 60
Insulation Test (2500 VAC)	Power to S.E.	Acc	[illegible]	22 PPG 60
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):			MAY 08 1995	22 PPG [illegible]
Light Transmittance:		74.8	MAY 08 1995	22 PPG [illegible]
Haze:		1.1	MAY 08 1995	PPG 60
Photo (Single Exposure):			MAY 09 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 3.0	2: 3.0	3: 4.0	4: 1.0	5: 1.0	6: 3.0
7: 4.0	8: .5	9: 1.0	10: 5.0	11: 3.0	12: 3.0

Dimensional Inspection: Acc MAY 08 1995 [illegible] PPG 60

Unit Thickness (per Template)

1: 1.50	2: 1.53	3: 1.49	4: 1.52	5: 1.50	6: 1.48
7: 1.52	8: 1.52	9: 1.50	10: 1.50	11: 1.49	12: 1.53

Edge Thickness (per Template)

1: .854	2: .850	3: .852	4: .850
5: .852	6: .850	7: .847	8: .852

Seal Evaluation: OK Acc [illegible] 1995 [illegible] PPG 60
(Comments)

Visual Inspection: Acc MAY 08 1995 [illegible] PPG [illegible]
(Place comments on attached sheet)

PPG PART NUMBER BAC-065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 86-H-07-14-260

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- OK

SEAL CONDITION- OK

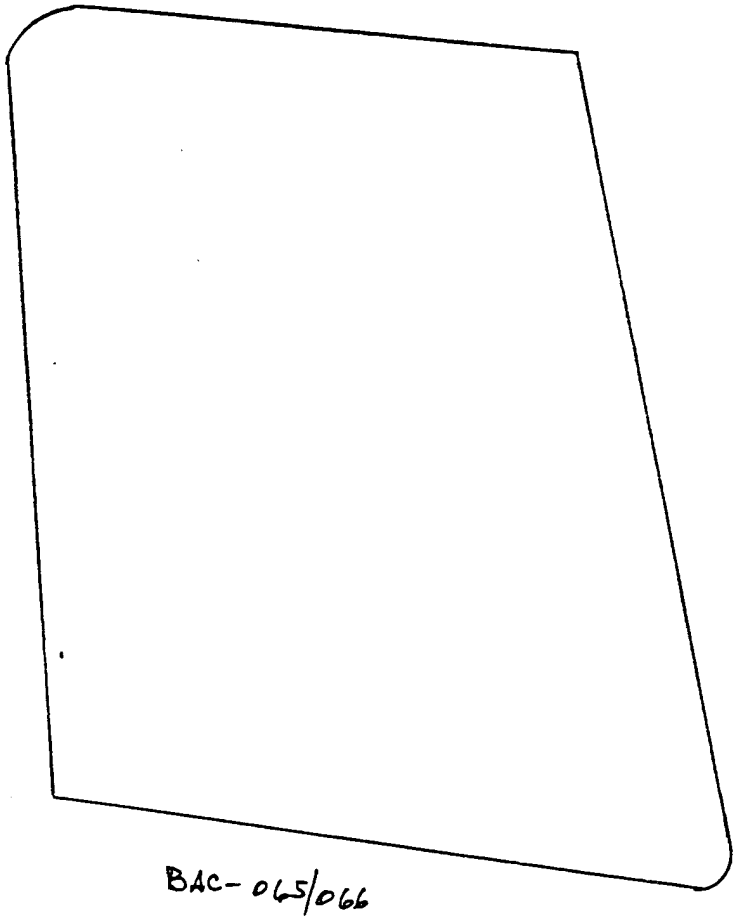
ELECTRICAL CONNECTOR CONDITION- OK

PPG PART NUMBER BAC-065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 86-H-07-14-260

VISUAL INSPECTION AND COMMENTS



BAC-065/066

OLD

PPG Part Number: BAC-065

Customer Part Number 10-30347-1

Unit Serial Number 91-277-H-0-574

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 71.8 Ω		Acc	MAY 08 1995	22 PPG
Thermal Image				
S.E. Resistance	30Ω	Acc	MAY 08 1995	22 PPG
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 08 1995	22 PPG
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):			MAY 08 1995	
Light Transmittance: 75.6		Acc	MAY 08 1995	
Haze: 1.1		Acc	MAY 08 1995	
Photo (Single Exposure):			MAY 09 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 4.0	2: 2.0	3: 2.0	4: 2.0	5: 2.0	6: 2.0
7: 2.0	8: 2.0	9: 2.0	10: 2.0	11: 2.0	12: 4.0

Dimensional Inspection: Acc MAY 08 1995 22 PPG 50

Unit Thickness (per Template)

1: 1.38	2: 1.30	3: 1.38	4: 1.36	5: 1.37	6: 1.35
7: 1.36	8: 1.37	9: 1.40	10: 1.36	11: 1.40	12: 1.40

Edge Thickness (per Template)

1: 862	2: 858	3: 854	4: 860
5: 864	6: 870	7: 852	8: 872

Seal Evaluation: Acc MAY 08 1995 22 PPG 50
(Comments)

Visual Inspection: (SEE CHART) Acc MAY 08 1995 22 PPG 51
(Place comments on attached sheet) 5/5

PPG PART NUMBER BAC-065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 91-277-H-0-574

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- SEE CHART

SEAL CONDITION- OK

ELECTRICAL CONNECTOR CONDITION- OK

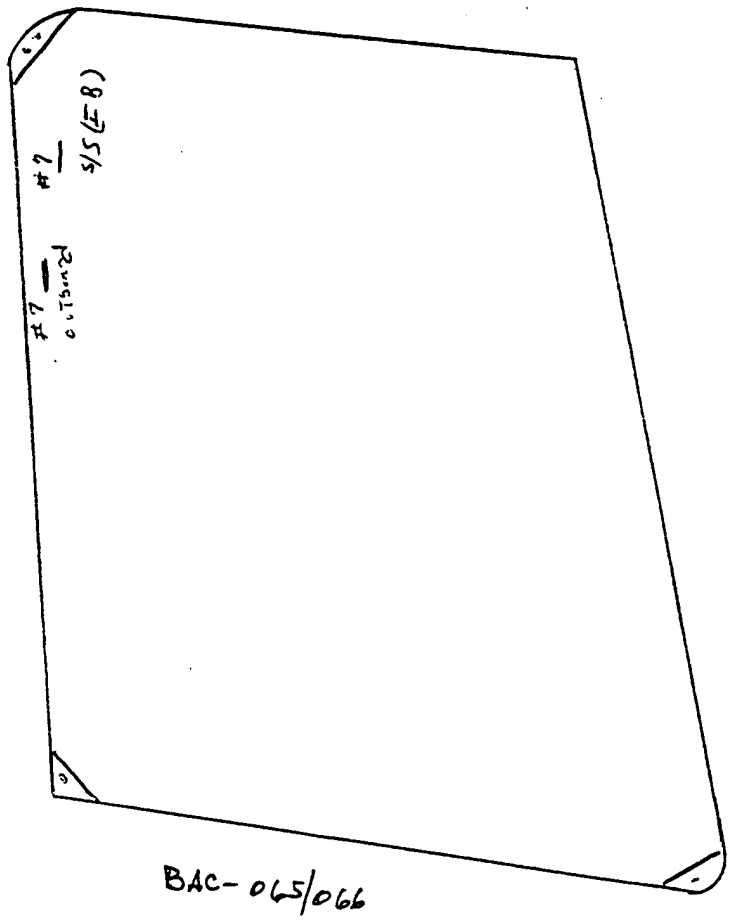
PPG PART NUMBER BAC-065

CUSTOMER PART NUMBER 10.30347-1

UNIT SERIAL NUMBER 91-277-H-0-574

VISUAL INSPECTION AND COMMENTS

ONE #1 S/S on Inboard ? OUTboard



BAC-065/066

PPG Part Number: Bac065

Customer Part Number 16-30347-1

Unit Serial Number 1-A-11-2-571

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 78.4 Ω		Acc.	MAY 11 1995	22 PPG 55
Thermal Image			5/15/95	22 PPG 55
S.E. Resistance 306		Acc	MAY 11 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 11 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 11 1995	22 PPG 55
Light Transmittance: 75.5		Acc.	MAY 11 1995	22 PPG 55
Haze: .8		Acc	MAY 11 1995	22 PPG 55
Photo (Single Exposure):			MAY 12 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 2.0	2: 2.0	3: 2.0	4: 1.0	5: 1.0	6: 2.0
7: 1.0	8: 3.0	9: 2.0	10: 4.0	11: 2.0	12: 4.0

Dimensional Inspection: eng diagram Acc MAY 11 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.038	2: 1.037	3: 1.039	4: 1.041	5: 1.042	6: 1.038
7: 1.039	8: 1.038	9: 1.040	10: 1.036	11: 1.036	12: 1.035

Edge Thickness (per Template)

1: .850	2: .852	3: .848	4: .830
5: .838	6: .840	7: .850	8: .848

Seal Evaluation: Acc. MAY 11 1995 22 PPG 55
(Comments) _____

Visual Inspection: MAY 11 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER 8ae865

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 1-H-11-2-571

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- OK

SEAL CONDITION- Good

ELECTRICAL CONNECTOR CONDITION- Good

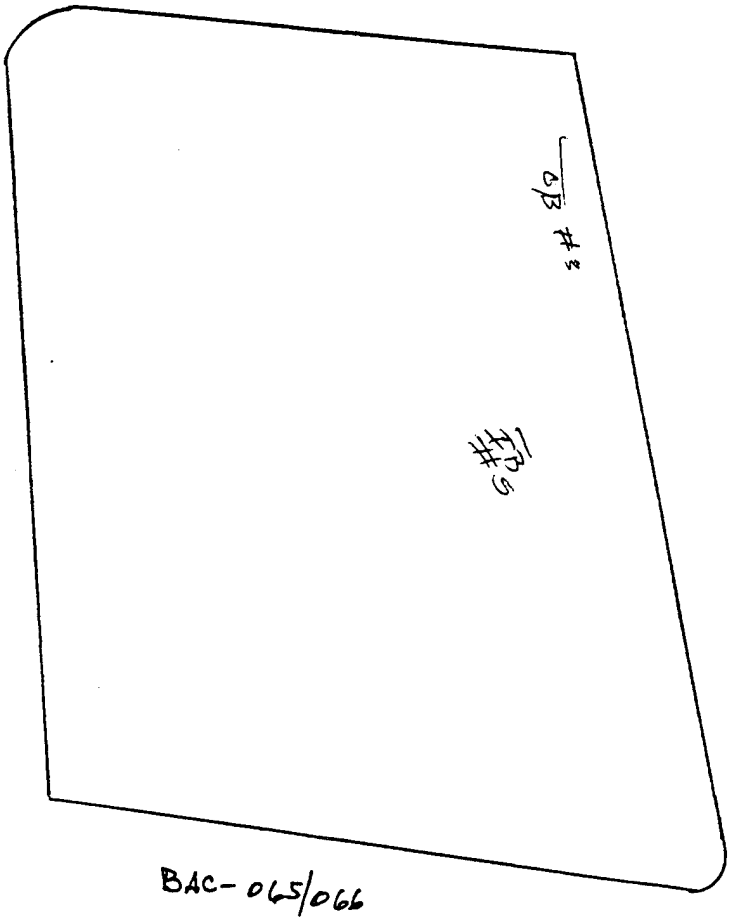
PPG PART NUMBER Bac 065

CUSTOMER PART NUMBER 10-3034-7

UNIT SERIAL NUMBER 1-A-11-2-571

VISUAL INSPECTION AND COMMENTS

Air in S/E



BAC-065/066

PPG Part Number: BAC-065

Customer Part Number 10-30347-1

Unit Serial Number 5-H-3-04-09

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 677 Ω		Acc	MAY 08 1995	22 PPG
Thermal Image			5/11/95	22 PPG
S.E. Resistance	310	Acc	MAY 08 1995	22 PPG
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 08 1995	PPG
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 08 1995	22 PPG
Light Transmittance:	76.4	Acc	MAY 08 1995	22 PPG 60
Haze:	1.1	Acc	MAY 08 1995	PPG 60
Photo (Single Exposure):			MAY 09 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 4.0	2: 4.5	3: 5.0	4: .5	5: 2.0	6: 3.0
7: 2.0	8: 3.0	9: .5	10: 2.0	11: 4.0	12: 4.0

Dimensional Inspection: Acc MAY 08 1995 22 PPG 60

Unit Thickness (per Template)

1: 1.43	2: 1.40	3: 1.40	4: 1.37	5: 1.36	6: 1.38
7: 1.34	8: 1.32	9: 1.40	10: 1.34	11: 13.7	12: 1.33

Edge Thickness (per Template)

1: 872	2: 868	3: 868	4: 858
5: 864	6: 862	7: 870	8: 867

Seal Evaluation: Acc MAY 08 1995 PPG 60
(Comments) SEE Chart

Visual Inspection: Acc 1995 23 PPG 60
(Place comments on attached sheet)

PPG PART NUMBER BAC-065

CUSTOMER PART NUMBER 10-30347-01

UNIT SERIAL NUMBER 5-H-3-04-09

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- SEE CHART

SEAL CONDITION- OK

ELECTRICAL CONNECTOR CONDITION- OK

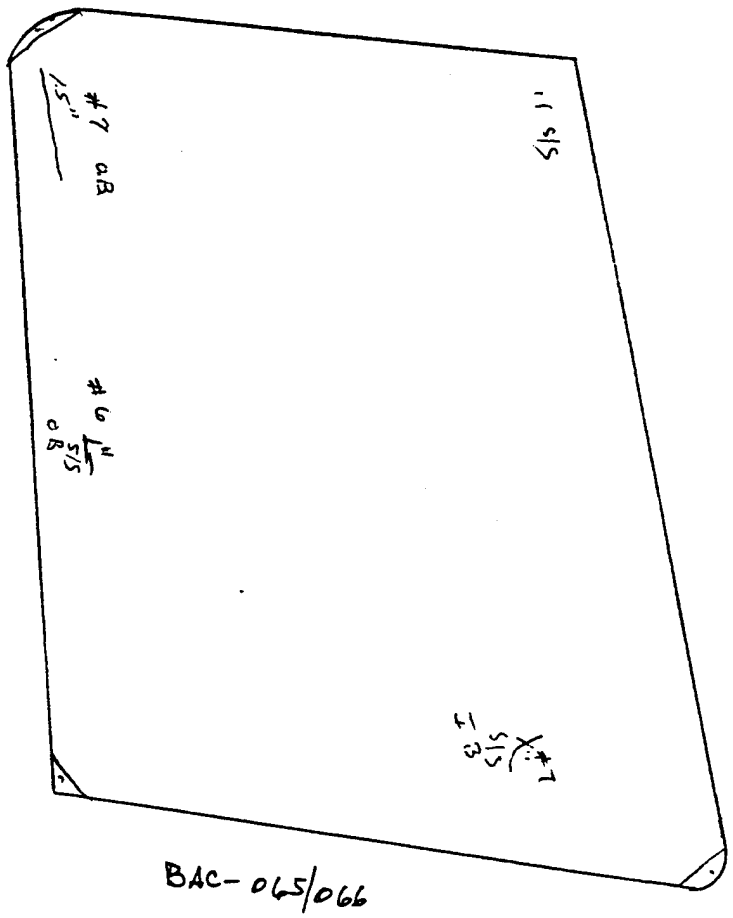
PPG PART NUMBER BAC-065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 5-H-3-04-09

VISUAL INSPECTION AND COMMENTS

S/S Air in SLIP PLANE



BAC-065/066

PPG Part Number: BAC-065

Customer Part Number 10-30347-1

Unit Serial Number 86-H-05-12-588

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 697 Ω		Acc	MAY 08 1995	22 PPG
Thermal Image			5/11/95	
S.E. Resistance 306		Acc	MAY 08 1995	22 PPG 60
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 08 1995	PPG 60
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 08 1995	PPG
Light Transmittance:		Acc 74.8	MAY 08 1995	
Haze:		.9	MAY 08 1995	PPG
Photo (Single Exposure):			MAY 09 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: .1	2: .2	3: .2	4: .3	5: .3	6: .4
7: .3	8: .2	9: .2	10: .4	11: .3	12: .4

Dimensional Inspection: Acc MAY 08 1995

Unit Thickness (per Template)

1: 1.60	2: 1.57	3: 1.58	4: 1.60	5: 1.53	6: 1.55
7: 1.57	8: 1.53	9: 1.58	10: 1.52	11: 1.54	12: 1.53

Edge Thickness (per Template)

1: 848	2: 854	3: 848	4: 854
5: 852	6: 850	7: 850	8: 848

Seal Evaluation: Acc MAY 08 1995
(Comments) SEE CHART

Visual Inspection: "SEE CHART" Acc MAY 08 1995
(Place comments on attached sheet)

PPG PART NUMBER BAC-065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 86-H-05-12-588

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- SEE CHART

SEAL CONDITION- OK

ELECTRICAL CONNECTOR CONDITION- OK

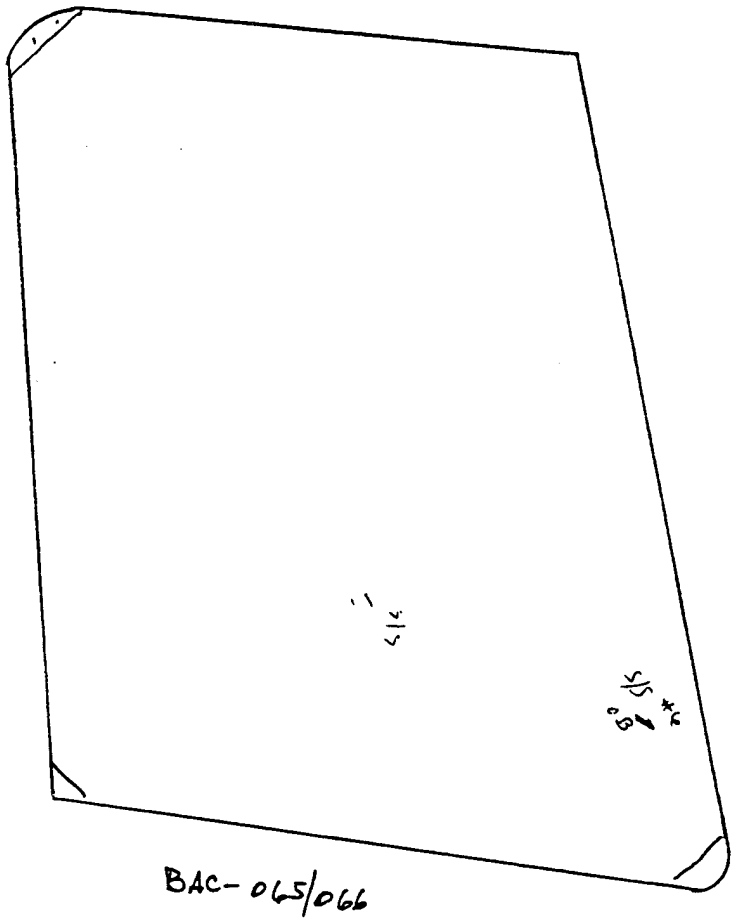
PPG PART NUMBER BAC-065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 86-H-05-12-588

VISUAL INSPECTION AND COMMENTS

SEE CHART.



BAC-065/066

PPG Part Number: Bac 065-

Customer Part Number 10-30347-1

Unit Serial Number 85-H-06-27-021

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 76.7 Ω		Acc	MAY 11 1995	22 PPG 55
Thermal Image				
S.E. Resistance 307		Acc	MAY 11 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 11 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 11 1995	22 PPG 55
Light Transmittance: 76		Acc	MAY 11 1995	22 PPG 55
Haze: ~~96~~ 98 1.4		Acc	MAY 11 1995	22 PPG 55
Photo (Single Exposure):			MAY 12 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 4.5	2: 4.5	3: 4.5	4: 4.5	5: 1.0	6: 1.0
7: 1.0	8: 1.0	9: 1.0	10: 4.5	11: 3.0	12: 3.0

Dimensional Inspection: egg Shape Idea Acc MAY 11 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.048	2: 1.048	3: 1.049	4: 1.044	5: 1.048	6: 1.047
7: 1.047	8: 1.044	9: 1.043	10: 1.050	11: 1.044	12: 1.047

Edge Thickness (per Template)

1: .844	2: .844	3: .830	4: .840
5: .830	6: .838	7: .840	8: .836

Seal Evaluation: Acc MAY 11 1995 22 PPG 55
(Comments) _____

Visual Inspection: See Sketch for Scratches Acc MAY 11 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bac 065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 88-H-06-27-021

VISUAL INSPECTION

DELAMINATION- OK.

VINYL CRACKS- OK

SCRATCHES- See Sketch

SEAL CONDITION- Good

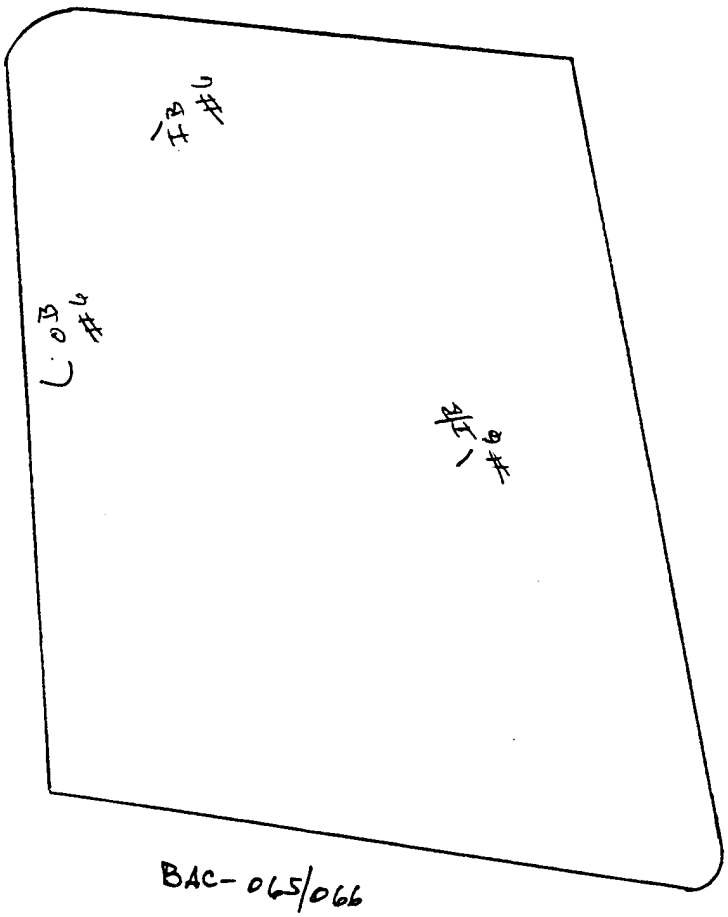
ELECTRICAL CONNECTOR CONDITION- Good

PPG PART NUMBER Bac. 065

CUSTOMER PART NUMBER 16-30347-1

UNIT SERIAL NUMBER 88-H-06-27-021

VISUAL INSPECTION AND COMMENTS



BAC-065/066

Used

PPG Part Number: Bac 065

Customer Part Number 10-30347-1

Unit Serial Number 1-H-11-2-592

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 21.0 Ω		Acc	MAY 11 1995	22 PPG 55
Thermal Image			5/15/95	
S.E. Resistance 310		Acc	MAY 11 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 11 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 11 1995	22 PPG 55
Light Transmittance: 74.8		Acc	MAY 11 1995	22 PPG 55
Haze: 1.1		Acc	MAY 11 1995	22 PPG 55
Photo (Single Exposure):			MAY 12 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 2.0	2: 2.0	3: 2.0	4: 3.0	5: 2.0	6: 1.0
7: 3.0	8: 2.0	9: 1.0	10: 3.0	11: 3.0	12: 3.0

Dimensional Inspection: Acc MAY 11 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.045	2: 1.044	3: 1.046	4: 1.043	5: 1.045	6: 1.047
7: 1.048	8: 1.043	9: 1.050	10: 1.047	11: 1.047	12: 1.046

Edge Thickness (per Template)

1: .850	2: .850	3: .858	4: .838
5: .838	6: .860	7: .867	8: .872

Seal Evaluation: Rej MAY 11 1995 22 PPG 55
(Comments) _____

Visual Inspection: _____ MAY 11 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bac 065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 1-N-11-2-572

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- See Sketch

SEAL CONDITION- Good

ELECTRICAL CONNECTOR CONDITION- Good

PPG PART NUMBER Bac 065

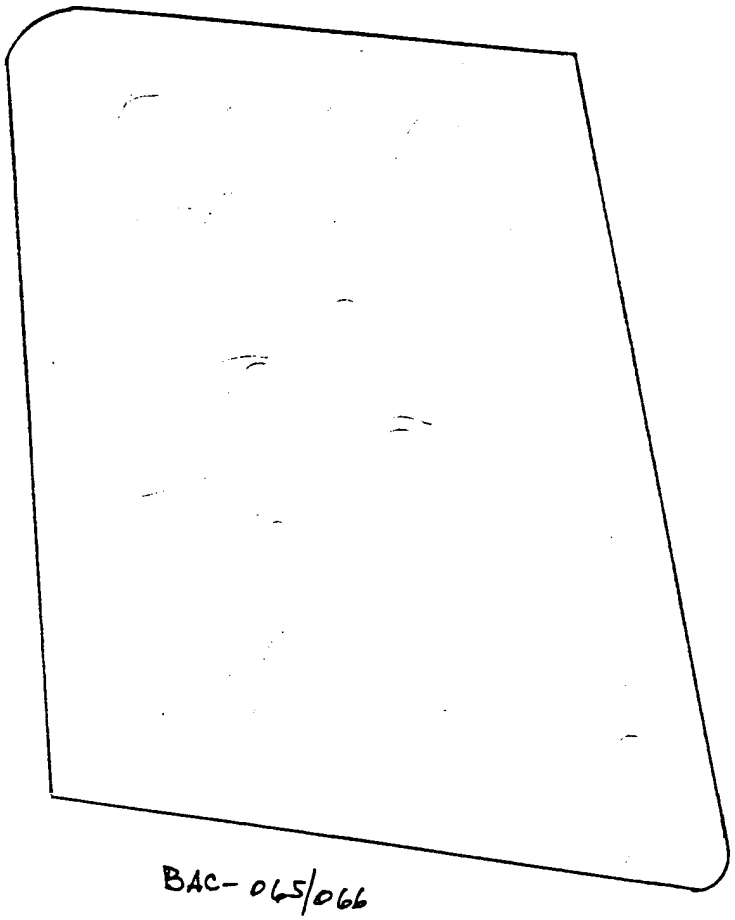
CUSTOMER PART NUMBER 16-30347-1

UNIT SERIAL NUMBER 1-N-11-2-572

VISUAL INSPECTION AND COMMENTS

Excessive Surface Scratch more larger than #7

Air in S/E



BAC-065/066

Used

PPG Part Number: Bac065

Customer Part Number 10-30347-1

Unit Serial Number 84-H-6-4-131

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 27.1 Ω		Acc	MAY 11 1995	22 PPG 55
Thermal Image			5/15/95	
S.E. Resistance 308		Acc	MAY 11 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 11 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 11 1995	22 PPG 55
Light Transmittance: 75.5		Acc	MAY 11 1995	22 PPG 55
Haze: 1.2		Acc	MAY 11 1995	22 PPG 55
Photo (Single Exposure):			MAY 12 1995	22 PPG 55

Deviation Inspection
(Per Template)

1: 1.0	2: 1.0	3: 1.0	4: 1.0	5: 2.0	6: 1.0
7: 2.0	8: 1.0	9: 2.6	10: 4.0	11: 7.0	12: 4.5

Dimensional Inspection: Acc MAY 11 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.035	2: 1.037	3: 1.045	4: 1.040	5: 1.041	6: 1.037
7: 1.040	8: 1.035	9: 1.038	10: 1.044	11: 1.040	12: 1.044

Edge Thickness (per Template)

1: .868	2: .863	3: .840	4: .858
5: .868	6: .800	7: .862	8: .860

Seal Evaluation: Rej. MAY 11 1995 22 PPG 55
(Comments)

Visual Inspection: MAY 11 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bae 065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 84-H-6-4-131

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- See Sketch

SEAL CONDITION- Poor

ELECTRICAL CONNECTOR CONDITION- Good

PPG PART NUMBER BAC 065

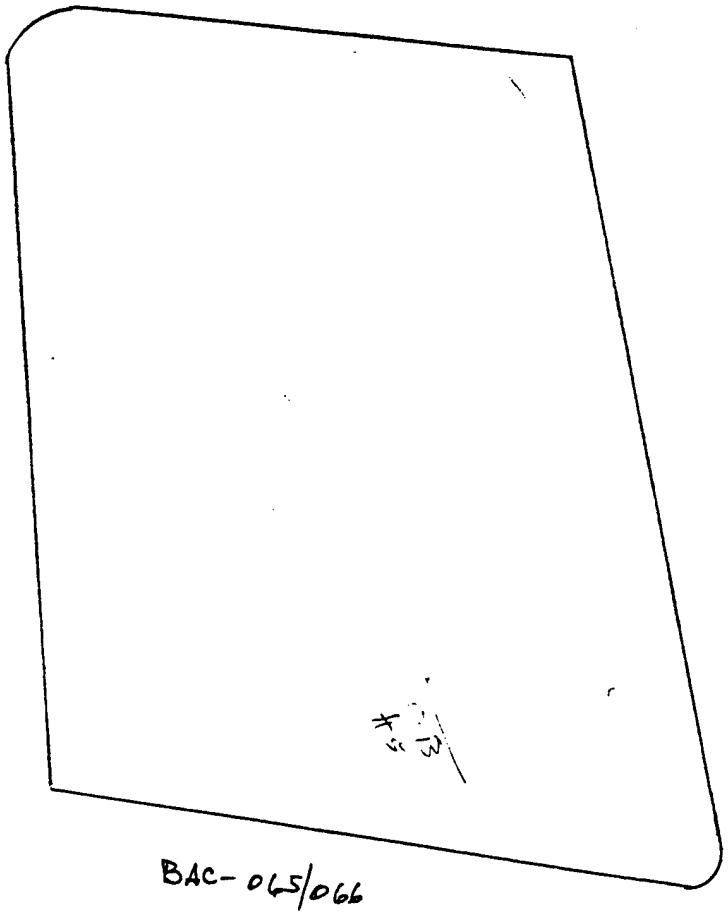
CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 84-H-6-4-131

VISUAL INSPECTION AND COMMENTS

light scratches all over some larger than #5

Air in S/E



BAC-065/066

PPG Part Number: Bac 065

Customer Part Number 10-30347-1

Unit Serial Number 86-N-11-17-342

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 84.4Ω		Acc	MAY 11 1995	22 PPG 55
Thermal Image			5/15/95	
S.E. Resistance 386		Acc	MAY 11 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 11 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 11 1995	22 PPG 55
Light Transmittance: 76.4		Acc	MAY 11 1995	22 PPG 55
Haze: .8		Acc	MAY 11 1995	22 PPG 55
Photo (Single Exposure):			MAY 12 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 3.0	2: 3.0	3: 3.0	4: 2.0	5: 2.0	6: 2.0
7: 3.0	8: 2.0	9: 2.0	10: 3.0	11: 3.0	12: 4.0

Dimensional Inspection: Acc MAY 11 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.056	2: 1.054	3: 1.060	4: 1.053	5: 1.056	6: 1.066
7: 1.062	8: 1.055	9: 1.058	10: 1.057	11: 1.055	12: 1.063

Edge Thickness (per Template)

1: .840	2: .830	3: .840	4: .848
5: .856	6: .850	7: .855	8: .820

Seal Evaluation: Rej MAY 11 1995 22 PPG 55
(Comments) _____

Visual Inspection: _____ MAY 11 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bac 065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- See Sketch

SEAL CONDITION- Poor

ELECTRICAL CONNECTOR CONDITION- Good

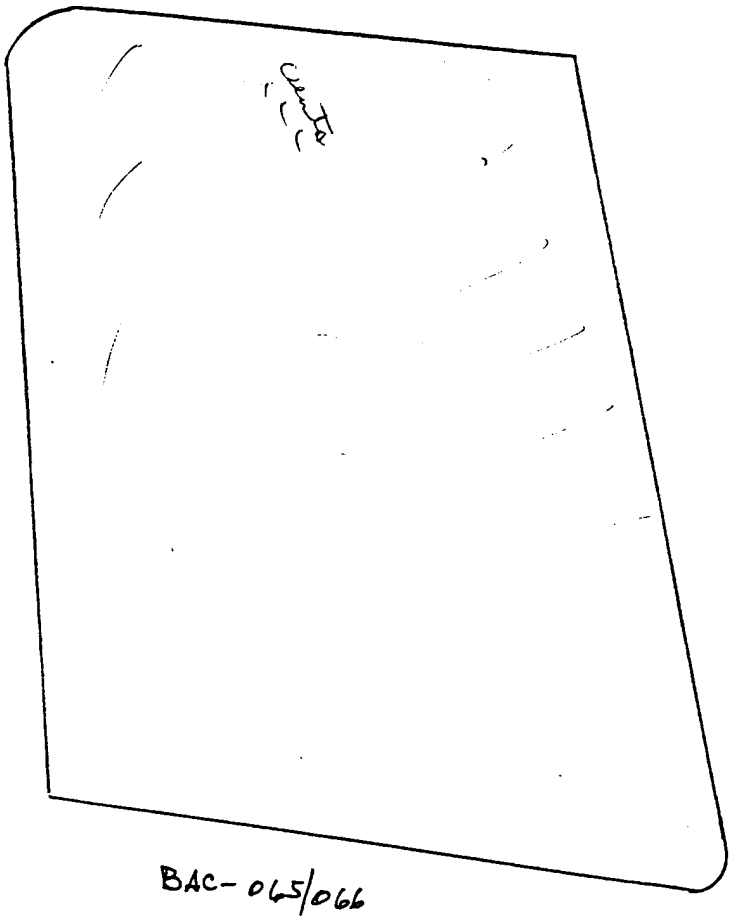
PPG PART NUMBER Bac 065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER

VISUAL INSPECTION AND COMMENTS

Excessive Scratches IB + OB more large than #7 Air in Big Plane



BAC-065/066

NEW

PPG Part Number: 3AC-065

Customer Part Number 10-30347-1

Unit Serial Number 92 199 HO 417

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 666 Ω		Acc	MAY 05 1995	22 PPG 60
Thermal Image			5/10/95	PPG 60
S.E. Resistance 30 Ω		Acc	MAY 05 1995	PPG 60
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 05 1995	PPG 60
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 05 1995	PPG 60
Light Transmittance: 73.8		Acc	MAY 05 1995	22 PPG 60
Haze: 1.1		Acc	MAY 05 1995	PPG 60
Photo (Single Exposure):			MAY 09 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: .5	2: 1.0	3: 4.0	4: .5	5: 2.0	6: 1.0
7: 1.0	8: 2.0	9: 2.0	10: 1.0	11: 2.0	12: 1.0

Dimensional Inspection: Acc MAY 05 1995 PPG 60

Unit Thickness (per Template)

1: 1.28	2: 1.24	3: 1.28	4: 1.25	5: 1.29	6: 1.30
7: 1.28	8: 1.32	9: 1.31	10: 1.36	11: 1.36	12: 1.37

Edge Thickness (per Template)

1: .827	2: 850	3: 847	4: 842
5: 832	6: 840	7: 862	8: 855

Seal Evaluation: OK MAY 05 1995 PPG 60
(Comments)

Visual Inspection: OK
(Place comments on attached sheet)

PPG PART NUMBER BAC-065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 92 199 HO 417

VISUAL INSPECTION

DELAMINATION- Acc

VINYL CRACKS- Acc

SCRATCHES- Acc

SEAL CONDITION- Good

ELECTRICAL CONNECTOR CONDITION- OK

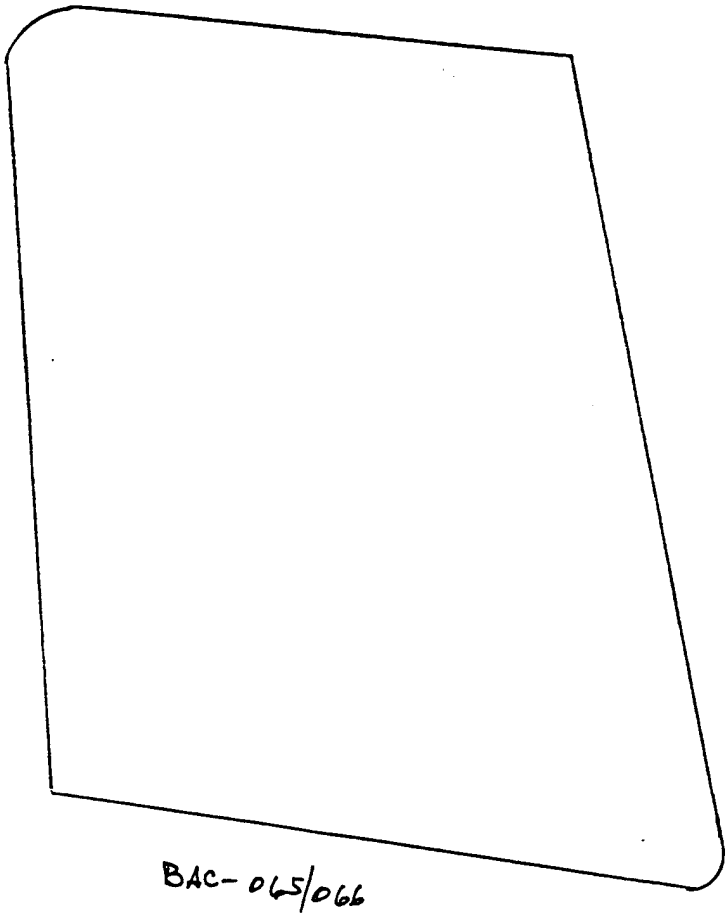
PPG PART NUMBER BAC-065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 92 199 HO 419

VISUAL INSPECTION AND COMMENTS

OK



BAC-065/066

7pcs

PPG Part Number: Bac065

Customer Part Number 10-30347-1

Unit Serial Number 92-199-210-423

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 63.2 Ω		Acc	MAY 11 1995	22 PPG 55
Thermal Image		G	5/15/95	22 PPG 55
S.E. Resistance 304		Acc	MAY 11 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	Acc	MAY 11 1995	22 PPG 55
	S.E. to Metal	Acc		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 11 1995	22 PPG 55
Light Transmittance: 76.6		Acc	MAY 11 1995	22 PPG 55
Haze: .8		Acc	MAY 11 1995	22 PPG 55
Photo (Single Exposure):			MAY 12 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 3.0	2: 2.0	3: 3.0	4: 1.0	5: 2.0	6: 1.0
7: 3.0	8: 2.0	9: 2.0	10: 1.0	11: 1.0	12: 30

Dimensional Inspection: Acc MAY 11 1995 22 PPG 55

Unit Thickness (per Template)

1: 1.038	2: 1.039	3: 1.042	4: 1.035	5: 1.034	6: 1.037
7: 1.035	8: 1.038	9: 1.035	10: 1.033	11: 1.031	12: 1.041

Edge Thickness (per Template)

1: .838	2: .880	3: .849	4: .832
5: .842	6: .830	7: .846	8: .838

Seal Evaluation: Acc MAY 11 1995 22 PPG 55
(Comments) _____

Visual Inspection: Acc MAY 11 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bae 065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 92-199-NO-423

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- None

SEAL CONDITION- Good

ELECTRICAL CONNECTOR CONDITION- Good

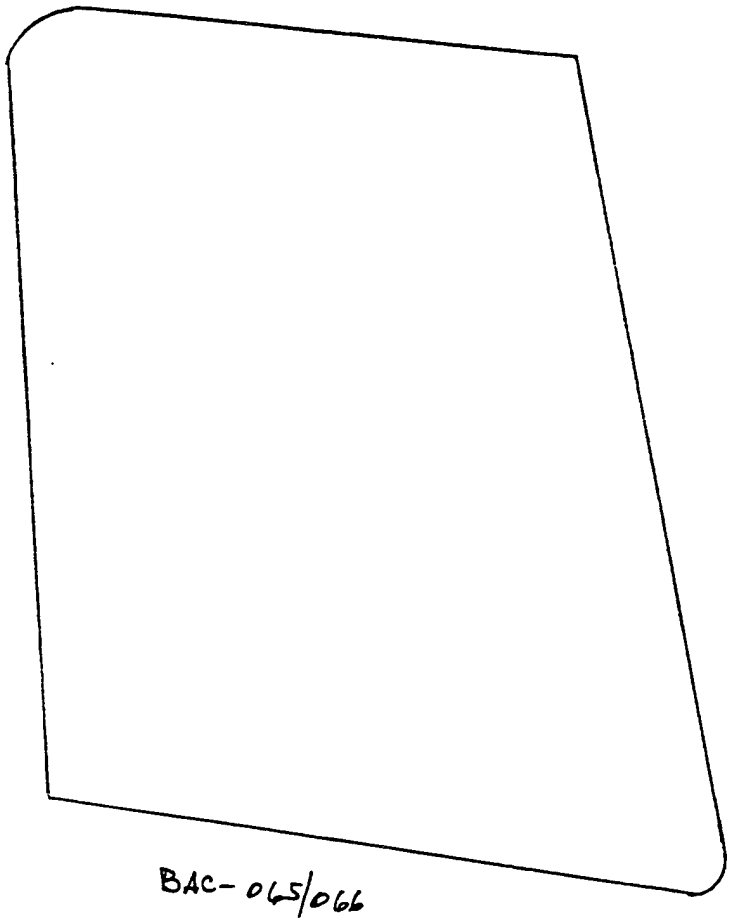
PPG PART NUMBER Bac065

CUSTOMER PART NUMBER 10-30347-1

UNIT SERIAL NUMBER 92-199 H0423

VISUAL INSPECTION AND COMMENTS

Good



BAC-065/066

PPG Part Number: Bac 106

Customer Part Number 16-1657-20

Unit Serial Number 84-A-11-19-090

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 68.8 Ω		Acc	MAY 11 1995	[illegible]
Thermal Image			5/15/95	
S.E. Resistance		N/A	MAY 11 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	N/A	MAY 11 1995	[illegible]
	S.E. to Metal	N/A		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 11 1995	[illegible]
Light Transmittance: 78.6		Acc	MAY 11 1995	22 PPG 55
Haze: 1.1		Acc	MAY 11 1995	22 PPG 55
Photo (Single Exposure):			MAY 12 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 4.5	2: 4.5	3: 4.5	4: 4.5	5: 4.5	6: 4.5
7: 4.5	8: 4.5	9: 4.5	10: 4.5	11: 4.5	12: 4.5

Dimensional Inspection: Acc MAY 11 1995 22 PPG 55

Unit Thickness (per Template)

1: .855	2: .850	3: .850	4: .853	5: .850	6: .854
7: .855	8: .855	9: .857	10: .858	11: .854	12: .860

Edge Thickness (per Template)

1: .835	2: .829	3: .780	4: .782
5: .810	6: .818	7: .815	8: .795

Seal Evaluation: N/A MAY 11 1995 22 PPG 55
(Comments) N/A

Visual Inspection: Acc MAY 11 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bac 106

CUSTOMER PART NUMBER 10-1657-20

UNIT SERIAL NUMBER 84-A-11-19-090

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- None

SEAL CONDITION- N/A

ELECTRICAL CONNECTOR CONDITION- Chipped T/B

PPG PART NUMBER Bac 106

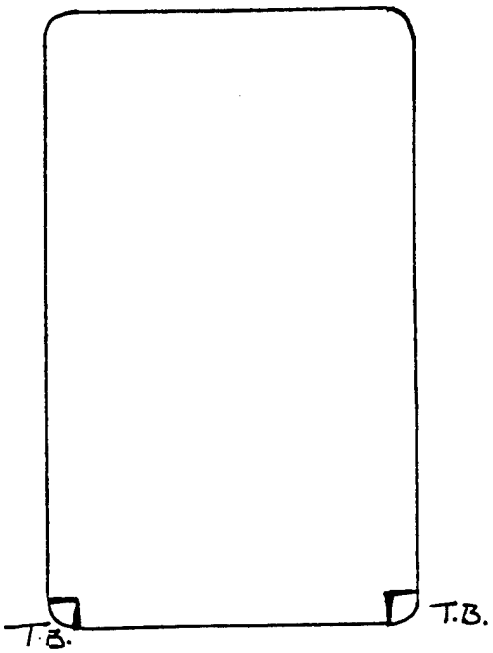
CUSTOMER PART NUMBER 10-1657-20

UNIT SERIAL NUMBER 84-A-11-19-090

VISUAL INSPECTION AND COMMENTS

Good

BAC-105/106
Convex surface
Shown



Used

PPG Part Number: Bac 166

Customer Part Number 16-1657-20

Unit Serial Number 85-H-02-18-621

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 77.4 Ω		Acc	MAY 11 1995	22 PPG 55
Thermal Image			5/15/95	
S.E. Resistance		N/A	MAY 11 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	N/A	MAY 11 1995	22 PPG 55
	S.E. to Metal	N/A		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 11 1995	22 PPG 55
Light Transmittance: 75.6		Acc	MAY 11 1995	22 PPG 55
Haze: .8		Acc	MAY 11 1995	22 PPG 55
Photo (Single Exposure):			MAY 12 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 4.0	2: 4.5	3: 4.5	4: 4.5	5: 4.0	6: 4.0
7: 4.0	8: 4.0	9: 4.5	10: 4.0	11: 4.5	12: 4.5

Dimensional Inspection: Acc MAY 11 1995 22 PPG 55

Unit Thickness (per Template)

1: .859	2: .860	3: .864	4: .856	5: .858	6: .860
7: .857	8: .859	9: .858	10: .855	11: .857	12: .859

Edge Thickness (per Template)

1: .820	2: .829	3: .832	4: .825
5: .820	6: .827	7: .830	8: .831

Seal Evaluation: N/A MAY 11 1995 22 PPG 55
(Comments) _____

Visual Inspection: Acc MAY 11 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER BAC 106

CUSTOMER PART NUMBER 10-1652-20

UNIT SERIAL NUMBER 85-N-02-18-621

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- See Sketch

SEAL CONDITION- N/A

ELECTRICAL CONNECTOR CONDITION- Good

PPG PART NUMBER BAC 106

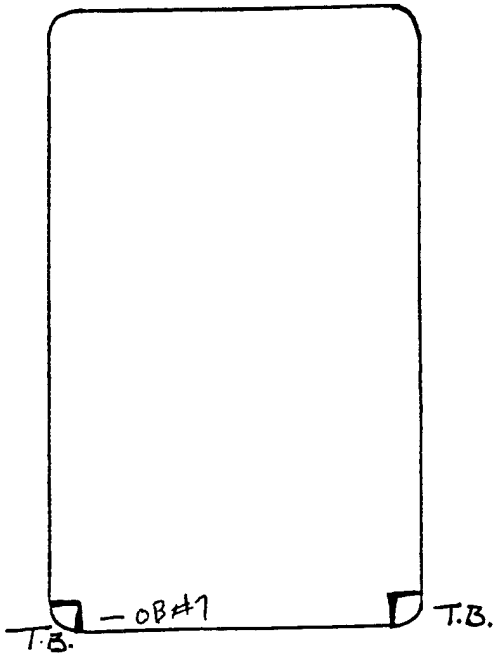
CUSTOMER PART NUMBER 10-1657-20

UNIT SERIAL NUMBER 85-14-02-18-621

VISUAL INSPECTION AND COMMENTS

Small Scratch on OB#6

BAC-105/106
Convex surface
Shown



Used

PPG Part Number: Bac 106

Customer Part Number 10-1657-20

Unit Serial Number 87-N-05-04-554

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 652 Ω		acc	MAY 11 1995	22 PPG 55
Thermal Image			5/15/95	
S.E. Resistance		N/A	MAY 11 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	N/A	MAY 11 1995	22 PPG 55
	S.E. to Metal	N/A		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		acc	MAY 11 1995	22 PPG 55
Light Transmittance: 77.7		acc	MAY 11 1995	22 PPG 55
Haze: 1.1		acc	MAY 11 1995	22 PPG 55
Photo (Single Exposure):			MAY 12 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 4.0	2: 4.5	3: 4.0	4: 4.5	5: 4.5	6: 4.0
7: 4.0	8: 4.0	9: 4.5	10: 4.0	11: 4.5	12: 4.5

Dimensional Inspection: acc MAY 11 1995 22 PPG 55

Unit Thickness (per Template)

1: .856	2: .858	3: .840	4: .858	5: .856	6: .856
7: .858	8: .858	9: .846	10: .856	11: .856	12: .860

Edge Thickness (per Template)

1: .790	2: .806	3: .828	4: .804
5: .820	6: .800	7: .812	8: .840

Seal Evaluation: N/A MAY 11 1995 22 PPG 55
(Comments) _____

_____

_____

Visual Inspection: acc MAY 11 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Bcc 106

CUSTOMER PART NUMBER 10-1657-20

UNIT SERIAL NUMBER 87-A-05-04-554

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- See Sketch

SEAL CONDITION- N/A

ELECTRICAL CONNECTOR CONDITION- Good

PPG PART NUMBER Bac 106

CUSTOMER PART NUMBER 10-1657-20

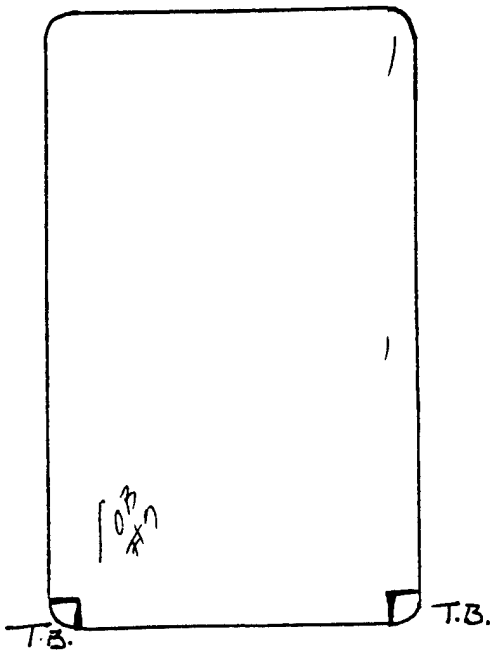
UNIT SERIAL NUMBER 87-H-05-04-554

VISUAL INSPECTION AND COMMENTS

6 Scratches on O/B Not Larger than #7

Scratch on I/B not Larger than #7

BAC-105/106
Convex surface
Shown



PPG Part Number: BAC106

Customer Part Number 10-1657-20

Unit Serial Number 88-H-09-19-253

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 67.2Ω		Acc	MAY 11 1995	22 PPG 55
Thermal Image			5/15/95	
S.E. Resistance		N/A	MAY 11 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	N/A	MAY 11 1995	22 PPG 55
	S.E. to Metal	N/A		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 11 1995	22 PPG 55
Light Transmittance: 78.2		Acc	MAY 11 1995	22 PPG 55
Haze: 1.2		Acc	MAY 11 1995	22 PPG 55
Photo (Single Exposure):			MAY 12 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 4.0	2: 4.0	3: 4.5	4: 4.5	5: 4.0	6: 4.5
7: 4.0	8: 4.5	9: 4.5	10: 4.0	11: 4.0	12: 4.5

Dimensional Inspection: Acc MAY 11 1995 22 PPG 55

Unit Thickness (per Template)

1: .850	2: .840	3: .848	4: .844	5: .846	6: .841
7: .841	8: .847	9: .844	10: .846	11: .850	12: .851

Edge Thickness (per Template)

1: .858	2: .860	3: .840	4: .845
5: .872	6: .832	7: .853	8: .835

Seal Evaluation: N/A MAY 11 1995 22 PPG 55
(Comments)

Visual Inspection: Acc MAY 11 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER BMC 106

CUSTOMER PART NUMBER 10-1657-20

UNIT SERIAL NUMBER 88-N-09-19-253

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES-

SEAL CONDITION- N/A

ELECTRICAL CONNECTOR CONDITION- Good

PPG PART NUMBER BAC 106

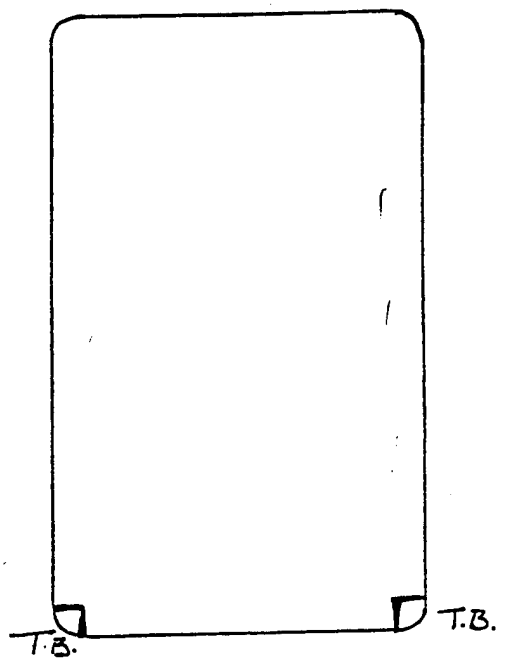
CUSTOMER PART NUMBER 10-1657-2C

UNIT SERIAL NUMBER 88-H-09-19-253

VISUAL INSPECTION AND COMMENTS

Light scratches O/B none larger than #2

BAC-105/106
Convex surface
Shown



PPG Part Number: Bac 106

Customer Part Number 16-1657-20

Unit Serial Number 92-100-HO-683

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 693Ω		Acc	MAY 11 1995	22 PPG 55
Thermal Image			MAY 15 1995	
S.E. Resistance		N/A	MAY 11 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	N/A	MAY 11 1995	22 PPG 55
	S.E. to Metal	N/A		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 11 1995	22 PPG 55
Light Transmittance: 79.8		Acc	MAY 11 1995	22 PPG 55
Haze: .9		Acc	MAY 11 1995	22 PPG 55
Photo (Single Exposure):			MAY 12 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 4.0	2: 4.0	3: 4.5	4: 4.0	5: 4.5	6: 4.5
7: 4.5	8: 4.5	9: 4.0	10: 4.0	11: 4.0	12: 4.5

Dimensional Inspection: Acc MAY 11 1995 22 PPG 55

Unit Thickness (per Template)

1: .845	2: .845	3: .844	4: .843	5: .836	6: .844
7: .842	8: .843	9: .843	10: .846	11: .844	12: .846

Edge Thickness (per Template)

1: .842	2: .844	3: .850	4: .852
5: .842	6: .844	7: .846	8: .848

Seal Evaluation: N/A MAY 11 1995 22 PPG 55
(Comments) _____

Visual Inspection: Acc MAY 11 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER BAC 106

CUSTOMER PART NUMBER 10-1657-20

UNIT SERIAL NUMBER 92-100-HO-683

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- None

SEAL CONDITION- N/A

ELECTRICAL CONNECTOR CONDITION- Good

PPG PART NUMBER BAC 106

CUSTOMER PART NUMBER 10-1652-20

UNIT SERIAL NUMBER 92-100-40-683

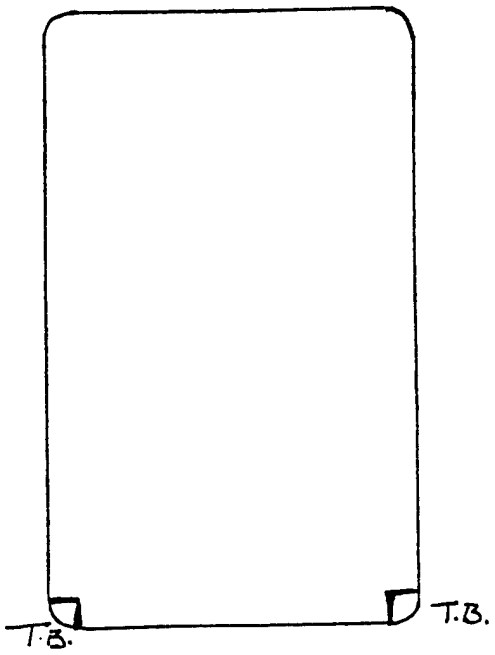
VISUAL INSPECTION AND COMMENTS

Good

BAC-105/106

Convex surface

Shown



PPG Part Number: BAC 106

Customer Part Number 10-1657-20

Unit Serial Number 94-208-H0-581

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 58.6 Ω		Acc	MAY 11 1995	22 PPG 55
Thermal Image			5/15/95	
S.E. Resistance		N/A	MAY 11 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	N/A	MAY 11 1995	22 PPG 55
	S.E. to Metal	N/A		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 11 1995	22 PPG 55
Light Transmittance: 77.9		Acc	MAY 11 1995	22 PPG 55
Haze: 1.1		Acc	MAY 11 1995	22 PPG 55
Photo (Single Exposure):			MAY 12 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 4.0	2: 4.5	3: 4.0	4: 4.5	5: 4.5	6: 4.0
7: 4.5	8: 4.5	9: 4.5	10: 4.0	11: 4.0	12: 4.5

Dimensional Inspection: Acc MAY 11 1995 22 PPG 55

Unit Thickness (per Template)

1: .854	2: .858	3: .848	4: .850	5: .854	6: .847
7: .837	8: .850	9: .855	10: .856	11: .850	12: .857

Edge Thickness (per Template)

1: .868	2: .858	3: .838	4: .833
5: .862	6: .868	7: .872	8: .840

Seal Evaluation: N/A MAY 11 1995 22 PPG 55
(Comments) _____

Visual Inspection: Acc MAY 11 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER BAC106

CUSTOMER PART NUMBER 10-1652-20

UNIT SERIAL NUMBER 94-208-HC-581

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- None

SEAL CONDITION- N/A

ELECTRICAL CONNECTOR CONDITION- Good

PPG PART NUMBER BAC 106

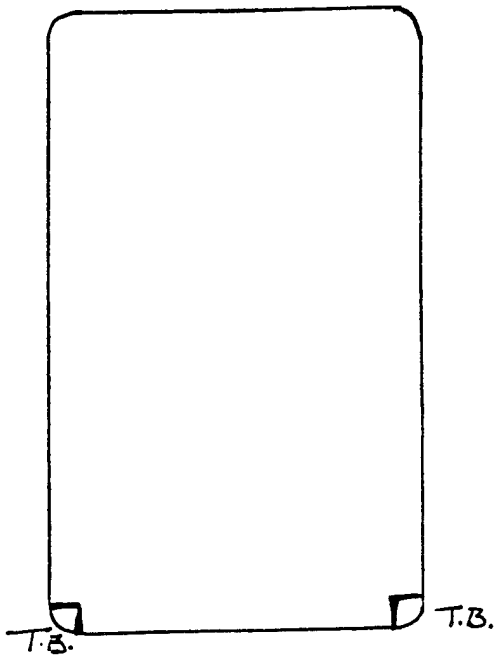
CUSTOMER PART NUMBER 10-1657-20

UNIT SERIAL NUMBER 94-208-A0-581

VISUAL INSPECTION AND COMMENTS

Good

BAC-105/106
Convex surface
Shown



PPG Part Number: Bac 106

Customer Part Number 10-1657-20

Unit Serial Number 94-249-NB-504

		Acc/Rej	Date	Inspector
Bus to Bus Resistance: 57.1 Ω		Acc	MAY 11 1995	22 PPG 55
Thermal Image			5/15/95	
S.E. Resistance		N/A	MAY 11 1995	22 PPG 55
Insulation Test (2500 VAC)	Power to S.E.	N/A	MAY 11 1995	22 PPG 55
	S.E. to Metal	N/A		
	S.E. to S.E.	N/A		
NESA Scratch Test (350 VAC):		Acc	MAY 11 1995	22 PPG 55
Light Transmittance: 77.2		Acc	MAY 11 1995	22 PPG 55
Haze: .9		Acc	MAY 11 1995	22 PPG 55
Photo (Single Exposure):			MAY 12 1995	22 PPG 23

Deviation Inspection
(Per Template)

1: 4.0	2: 4.5	3: 4.5	4: 4.0	5: 4.0	6: 4.5
7: 4.5	8: 4.0	9: 4.5	10: 4.0	11: 4.5	12: 4.0

Dimensional Inspection: Acc MAY 11 1995 22 PPG 55

Unit Thickness (per Template)

1: .840	2: .836	3: .842	4: .835	5: .841	6: .843
7: .842	8: .841	9: .839	10: .840	11: .842	12: .837

Edge Thickness (per Template)

1: .832	2: .835	3: .860	4: .861
5: .844	6: .848	7: .852	8: .850

Seal Evaluation: N/A MAY 11 1995 22 PPG 55
(Comments) _____

Visual Inspection: Acc MAY 11 1995 22 PPG 55
(Place comments on attached sheet)

PPG PART NUMBER Exc 106

CUSTOMER PART NUMBER 10-1651-20

UNIT SERIAL NUMBER 94-249-#0-504

VISUAL INSPECTION

DELAMINATION- OK

VINYL CRACKS- OK

SCRATCHES- None

SEAL CONDITION- N/A

ELECTRICAL CONNECTOR CONDITION- Good

PPG PART NUMBER Bac 106

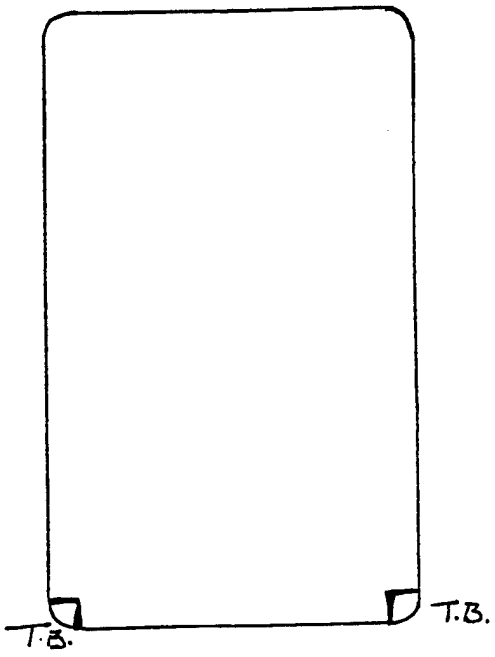
CUSTOMER PART NUMBER 10-1657-20

UNIT SERIAL NUMBER 94-249-HO.504

VISUAL INSPECTION AND COMMENTS

Good

BAC-105/106
Convex surface
Shown



APPENDIX D

B-52 W/WS BIRD IMPACT DATA SHEETS

Part	PPG	Window	Test Conditions				Timing Lights (ft/sec)				Speed	Results
Number	Shot #	Condition	Temp °F	Humid %	Pressure	Pkg Wt lb	Horizontal	Angular	Vertical	Average	(Knots)	
8-H-11-20-277	934	Repaired	76	85	38.2	3.97	681.9	679.3	680.9	680.7	403	Both plies failed, Penetration
86-H-07-H-260	935	Repaired	74	59	10.4	4.015	343.9	344	342.3	343.4	203	Pass No damage
5-H-3-20-17	936	Repaired	77	79	20.9	4.025	522.6	520.8	520.7	521.37	308	Outbd ply failed
92-199-HO-423	937	NEW	75	86	20.8	4.04	524.9	521.8	520.7	522.47	309	Pass No damage
84-11-6-4-131	938	Unrepaired	80	76	20.7	4.03	529	526.5	526.7	527.4	312	Pass No Damage
91-277-HO-574	939	Repaired	77	85	20.6	4	517.3	520.2	517.2	518.23	306	Both plies failed, 16 bolts broken
5-H-3-04-09	940	Repaired	85	72	20.5	3.93	520.1	517.2	516.5	517.93	306	Both plies failed
88-H-06-27-021	941	Repaired	82	77	20.4	4.04	512.8	511.4	508	510.73	302	Both plies Failed, 16 bolts broken
8-H-11-20-436	942	Repaired	79	72	20.4	4.02	512.7	511.9	511	511.87	303	Pass, No Damage
83-H-3-21-110	943	Repaired	72	95	20.4	4.015	521.2	518.1	515.8	518.37	306	Both plies failed, Penetration
86-H-03-17-221	944	Unrepaired	78	91	10.4	3.97	349.4	349.1	347.2	348.57	206	Pass no damage
86-H-03-03-298	945	Repaired	71	89	14.5	4.06	358.7	359.2	n/a	358.95	212	Outbd ply failed
87-H-11-30-749	946	Unrepaired	72	87	14.5	4.005	425.9	424.3	422.8	424.33	251	Pass no damage
9-H-11-19-503	947	Unrepaired	73	89	20.4	4.06	518.5	515.7	514.6	516.27	305	Both Plies Failed, Penetration
87-H-11-02-614	948	Repaired	80	87	14.5	4.03	425.5	424.2	422.9	424.2	251	Pass no damage
94-034-HO-742	949	New	73	93	14.7	4.03	425.6	423.4	423.6	424.2	251	Pass no damage
87-H-1-02-396	950	Repaired	74	93	14.5	4.025	419.6	418.5	416.9	418.33	248	Pass no damage
89-H-137-HO-1	951	Repaired	70	88	14.5	4.025	416.2	415.1	414.9	415.4	246	Pass no damage
86-H-04-28-683	952	Repaired	76	88	14.7	4.01	423.5	422.6	420.8	422.3	250	Both plies failed, Penetration

TEST NO.	934		4/26/95 Ballistics 065 Battelle/fsb 10-30397-1 / 8-H-11-20-29 Repaired
SPEED	400 KTS		
PRESS.	38.2 PSI		
IMPACT PT.	Center		
BIRD	3.930		
PACK	3.97		
... SABOT	AL AV		
T. TEMP.	76°F		
L. TEMP.	79°F		
HUM.	85%		
DIAP.	.005		
HOR.	.0073924	681.91	
~~VER~~ Mid			680.73 ~~KTS~~
	.0044159	699.36	
VER.	.0043815	680.94	403.06 Kts.
OBSERV:	Air		

7/27/95

Boeing 65
Battelle Lab
10-30347-1 / BL-H-07-H-2x
Repaired

-20-277

TEST NO. 935

SPEED 200 Kts

PRESS. 10.4 PSI

IMPACT PT. Center

BIRD 3.810

PACK 4.015

... SABOT Al Alv

T. TEMP. ~~-2°F~~

L. TEMP. 72°F

HUM. 59%

DIAP. .0081

HOR. .0087090 343.9

~~VER~~ mid .0087204 344.0 343.4

VER .0087170 342.3 203.34 Kts.

Obsvn: PASS

TEST NO.	936
SPEED	308 Kts
PRESS.	20.9 20.9 psi
IMPACT PT.	Center
BIRD	3.975
PACK	4.025
... SABOT	A/N
T. TEMP.	77°F
L. TEMP.	76°F
HUM.	19%
DIAP.	.002
HOR.	.0054312 ∫22.61
~~VER~~ mid	.0057598 ∫20.85
VER	.0057301 ∫20.79
Obsvr:	Only 0/B 4th Ply Broken

7/27/95
Boeing 65
Battelle Labs
10-30349-1 / 5-H-3-20-17
Repaired

∫21.41 FPS
308.7 Kts

7/28/95

Boeing 025

Battelle/Lon

10-30347-1 / 92-119-H-0-423

New

TEST NO. 937

SPEED 308 kts

PRESS. 20.8

IMPACT PT. Center

BIRD 3.925

PACK 4.04

SABOT Al HV

T. TEMP. 73°F

L. TEMP. 75°F

HUM. 86%

DIAP. .002

HOR. .0057058 524.9

VEL mid .0057286 521.8

VEL .0057307 520.7

522.5 FPS

309.3 kts

OBSRV: pass

TEST NO. 938

4/28/95

SPEED 300 Kts

Boeing 065

PRESS. 20.7

Battelle Labs

10-30347-1/84-11-6-4-131

IMPACT PT. Center

LAN Repaired

BIRD 3.985

PACK 4.03

... SABOT ALLV

T. TEMP. 80°F

L. TEMP. 75°F

HUM. 46%

DIAP. .002

HOR.	.00 5 6616	529.03	
~~VEL~~ mid	.00 56979	526.5	527.4 FPS
VEL	.00 56657	526.7	312.2 Kts

OBS & W: JHS

7-31-95
Boeing - 065
Battelle Jobs
91-277-HO-574
Repaired

TEST NO.	939	
SPEED	300 RPS	
PRESS.	20.6	
IMPACT PT.	Center	
BRNG	3.89	
PROJ.	4.00	
... CAGE	ALVH	
R. TEMP.	R.T. 77°F	
L. TEMP.	78°F	
HUM.	85%	
CLEAR.	.002	
HOR.	.00 ∫1900	∫17.30
VER. MID	.00 ∫1766	∫20.28 ∫18.26 FPS
VER.	.00 ∫1700	∫17.19 30.86 KBS

Observ. Broke I/B & O/B alley - witness Plate was Broken once on Top Right Hand Shoulder
Bolts Broken - 16 Top 8 1/2 Way Down Side

7-31-95
Boeing - 065
Battelle Labs
5-H-3-04-09
Repaired

TEST NO. 940

SPEED 300 kts

PRESS. 20.5

IMPACT PT. Center

BIRD 3.93

PACK 4.02

... SABOT ALVH

T. TEMP. 85°F

L. TEMP. 85°F

HUM. 72%

DIAP. .002

HOR. .00[7]592 [20.1

[17.9 FPS

VER. MID .00[8]005 [17.2

306.4 KTS

VER. .00[7]776 [16.[

Obsv. Failed F/B 1 O/B plier

TEST NO. 941 8/.195
Battelle Labs
SPEED 300 Kts Boeing 065
10-30[illegible]1 / 88-A-06-27-021
PRESS. 20.4 PSI Repaired
IMPACT PT. Center
GRD 3.830
PROX 4.04
SABOT ALV
I. TEMP. 22°F
L. TEMP. 78°F
[redacted] 77%
DIAP. .002
VOR. .0058405 512.8
510.7 Kts
mid .0058662 511.4
302.4 Kts
VER. .0058743 508.0
OBSERV: Failed 1/8 & 9/8 plies of Glass.
Broke 16 Bolts
witness plate Recived spall on Left Shoulder.

8/1/95
Battelle Labs
Boeing 065
10-303471/8-H-11-20-436
Repaired

06-27-021

TEST NO. 942

SPEED 300 kts

PRESS. 20.4 PSI

IMPACT PT. Center

BIRD 3.845

PACK 4.02

SABOT Alw

T. TEMP. 79°F

L. TEMP. 80°F

HUM. 72%

DIAP. .002

HOR. .00584 10 512.78

mid .00585 97 511.97 511.9 FPS

VER .00589 5 511.03 303.1 kts

OBSRV: PASS

54

TEST NO. 943 8/8/95

SPEED 300 Kts Battelle Labs

PRESS. 20.4 PSI Racing 061

IMPACT PT. Center #83H-3-21-110

BIRD 3.955 REPAIRED

BACK 4.015

.. SABOT Alum

.. TEMP. 72°F

.. TEMP. 72°F

HUM. 95%

DIAP. .002

HOR .00 S7466 S21.21

S18.36

VERmid .00 S7506 S18.08

306.9 Kts

VER .00 S7854 S15.81

OBSRV: Failure

8/8/95
BATTELLE LABS
BAC-061
#86-H-03-17-2
UNREPAIRED

TEST NO. 944

SPEED 200 KTS

PRESS. 10.4 PSI

IMPACT PT. Center

BIRD 3.970

PACK 4.03

SABOT ALV

T. TEMP. 78°F

L. TEMP. 78°F

HUM. 91%

DIAP. .001

HOR.	.0085716	349.43	
~~VERT~~	.0085928	349.12	348.57
VEL.	.0085957	347.17	206.4 KTS

Observ. PASS

56

TEST NO.	945	8/[illegible]/95
SPEED	250KB	[illegible]
PRESS.	14.5	[illegible]
		10-30347.7/86H0303298
IMPACT-PT.	Center	REPAIRED
BIRD	4.0	
PACK	4.06	
... SABOT	[illegible]	
T. TEMP.	71°F	
L. TEMP.	41°F	
HUM.	89%	
DIAP.	.0015	
HOR.	.0083485	358.77FPS
~~VER.~~ mid	.0083529	359.15 / 359.0
VER.	~~.02399[illegible] 121.4~~	212.5
OBSERV;	OB. PLY Broke & No Film	

TEST NO. 946 — 8/10/93

SPEED 250 KTS — Battelle Labs Inc-661

PRESS. 14.5 — 10-30347-7 / 87-H-11-30-749

IMPACT PT. Center

BIRD 3.955

PACK 4.005

SABOT A/LV

T. TEMP. 72°F

L. TEMP. 72°F

HUM. 47%

DIAP. .002

HOR.	.0070333	425.81	424.33 FPS
~~VER~~ M.I	.0040699	424.33	
VER	.0070581	422.80	251.24 KTS

OBSV. PASS

8/11/95
Battelle Lab
Bac 061
10-30344-7 / 9-41-11-19.5

TEST NO.	9A7
SPEED	300 Kts
PRESS.	20.4 PSI 20.4
IMPACT PT.	Center
BIRD	4.005
PACK	4.06
... SABOT	Al LV
T. TEMP.	73°F
L. TEMP.	73°F
HUM.	89%
DIAP.	.002
HOR.	.005 47462 5 18.54
~~VER.~~ mid	.005 8167 5 15.75 5 16.29
VER.	.005 7991 5 14.59 305.7 Kts.

Obsrv: Initial - Blew out center of window

TEST NO. 94B

8-17-95
Battelle Labs
Bac-061
87-H-11-02-614

SPEED 250 Kts

PRESS. 14.5

IMPACT PT. center

BIRD 3.65

PACK 4.03

SABOT A/LV

T. TEMP. 80°F

L. TEMP. 80°F

HUM. 87%

DIAP. .002

HOR.	.0070392	422.5
VERT.	.0070726	424.2
VEL	.0070540	422.9

424.2 fps

251.2 Kts

OBSERV: PASS

8-21-95
BATTELLE LABS
BAC-001
94-034-H0-742

TEST NO.	949		
SPEED	250 KNOTS		
PRESS.	14.7		
IMPACT PT.	Center		
BIRD	3.975		
PACK	4.03		
SABOT	ALVH		
T. TEMP.	RT		
L. TEMP.	73°F		
HUM.	93 90		
DIAP.	.002		
HOR.	.0070379	425.58	424.22 ft/sec
~~VER.~~ MID	.0070850	423.43	
VER.	.0070442	423.64	251.34 KTS
OBSERV	PASS, NO DAMAGE		

T38 Bird Sh

TEST NO. 950

SPEED 250

PRESS. 14.5

IMPACT PT. center

BIRD ~~3995~~ ~~3995~~ ~~3995~~ 3960

PACK 4.025

...SABOT ALV

T. TEMP. RT

L. TEMP. 74°F

HUM. 93%

DIAP. .002

HOR. .0041348 419.62 418.37 fps

~~VERT~~ Mid .0071677 418.54 247.7 KTS

VEL. .0071573 416.94

Observ: PASS

8/29/95
Battelle Labs
RAC-02 I
87-H-11-02-396

TEST NO. 951

8/30/85

SPEED 230 Kts

BATTELLE UTRS

PRESS. 14.5 PSI

BAC-061

89-H-137-HO-152

IMPACT PT. Center

BIRD 3.925

PACK ~~4.015~~ 4.025

SABOT ALV

T. TEMP. 70°F

L. TEMP. 70°F

HUM. 88%

BAR. .002

HOR. .0041954 416.26

~~Vert~~ mid .0047262 415.15

415.45 FPS

VEL. .0071920 414.93

1460 Kts

OVERALL: PASS

4/31/95

BATTELLE LABS
BAC-061
~~SS-H6-H0-366~~
86-H-0425-693

TEST NO. 952

SPEED 250 Kts

PRESS. 14.7

IMPACT PT. Center

BIRD 3.95

PACK 4.01

... SABOT ALVH

T. TEMP. 76°F

L. TEMP. 76°F

HUM. 88%

DIAP. .002

HOR .0070727 423.48 422.3

~~VER~~ Mid .0070989 422.6

VEL .0070911 420.83 250.0 Kts

Obsv: FAIL